The Engineer.

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The Engineer

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PUBLIC NOTICES

HEATING.

The Commissioners of His Majesty's Works, &c., are prepared to receive TENDERS before 11 a.m. on Wednesday, 27th June, 1928, for ACCELERATED LOW-PRESSURE HOT WATER HEATING and SUPPLY APPARATUS at the "City" Telephone Exchange, Chapel-street, Salford, Manchester.

Drawings, specification, a copy of the conditions and form of contract, bills of quantities and forms for Tender may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles-street, London, S.W. 1, on payment of One Guinea. (Cheques payable to the Commissioners, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. 8678

R.A. 2619.

Ministry of Transport. RYE-WINCHELSEA ROAD.
CONSTRUCTION OF REINFORCED CONCRETE BRIDGE OVER THE RIVER BREDE AT WINCHELSEA.

The Minister is prepared to receive TENDERS for the CONSTRUCTION and MAINTENANCE of a REINFORCED CONCRETE BRIDGE over the River Brede adjacent to the existing Strand Bridge near Winchelsea, East Sussex.

Form of Tender, conditions of Tender, conditions of contract, bill of quantities and specification may be obtained from the Chief Engineer, Roads Department, Ministry of Transport, 7, Whitehall-gardens, S.W. 1 (Room No. 135), upon payment of a deposit of £5. This amount will be returned to the tenderer if his Tender is a bona fide one and has not been withdrawn prior to the definite acceptance of a Tender by the Minister.

Copies of the above-mentioned Tender documents will be available for issue and the drawings may be inspected on and after Wednesday, the 13th June, 1928.

Tenders on the official form, each accompanied by a fully priced bill of quantities, must be enclosed in sealed envelopes, marked "Tender for River Brede Bridge," and submitted to the undersigned on or before 10 a.m. on Wednesday, the 27th day of June, 1928. The Minister does not bind himself to accept the lowest or any Tender.

Dated this 5th day of June, 1928.
(Sgd.) H. H. PIGGOTT,
Assistant Secretary.
Roads Department, Ministry of Transport. 8679

Assistant Works Manager REQUIRED for the FEDERATED MALAY STATES RAILWAY for four years, with prospect of permanency. Salary 600 dollars a month, rising to 800 dollars a month by annual increments of 25 dollars a month, plus a strictly temporary cost-of-living allowance of 10 per cent. of salary for single men and 20 per cent. for married men. The Government rate of exchange is now 2s. 4d. to the dollar, but the purchasing power of the dollar in Malaya is at present considerably less than that of 2s. 4d. in the United Kingdom. Free passages and, if married, for wife and children also under certain conditions. Candidates, aged 25 to 35, must have served an apprenticeship or pupilage in the Locomotive Department of a British Railway or with a firm of locomotive builders and have had experience of works management and of locomotive running conditions. They should have passed the A.M.I.C.E. Examination or hold an equivalent qualification and must have had some drawing-office experience.—Apply at once by letter, stating age, qualifications and particulars of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/578. 8650

Civil Engineer Required by the GOVERNMENT of JAMAICA for three years' service, with possible extension. Salary £600, rising to £700 a year by annual increments of £50. Free passages. Candidates, between 30 and 40 years of age, must be Chartered Civil Engineers who have had sound experience on Public Works, preferably in a Public Works Department. Must be able to make surveys and prepare such plans, reports, estimates and specifications as are usually required in a Public Works Department, and generally to assist the Director of Public Works in the control and management of the Department.—Apply at once by letter to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, stating age, qualifications and experience, quoting M/743. 8714

Wanted for the Indian ORDNANCE FACTORIES.
GUN CARRIAGE FACTORY, JUBBULPORE, CENTRAL PROVINCES.
An ASSISTANT WORKS MANAGER.

Salary Rupees 550 a month plus £25 a month sterling overseas pay, rising by annual increments of Rs. 50 a month to Rupees 750 plus £25. The appointment is non-pensionable, but there is a Provident Fund, to which Government contributes. Free passage to India is provided and quarters, if available, at a rental not exceeding 10 per cent. of salary. An agreement for five years will be entered into in the first instance.

Candidates must be well educated, must have obtained a University Degree in Engineering or have passed the A.M. Inst. C.E. Examination or have obtained some other corresponding qualification in engineering, and must in addition have had at least 3 years' practical experience of mechanical engineering under a qualified Civil Engineer.

Candidates must be between the ages of 24 and 36 years.

The selected officer will be required to proceed to India by the middle of September.

Applications should be submitted by the 15th July on forms to be obtained from the SECRETARY, Military Department, India Office, S.W. 1. Envelopes should be marked "Recruitment."

Applications from candidates who are outside the limits of age or do not possess the requisite qualifications cannot be considered. 8660

For Sale. At NASSAU, N.P., BAHAMAS, B.W.I., ONE 8 Cubic Yard Steel British Harbour Type DREDGER, built in 1923 by Lobnitz and Co., Renfrew, Scotland, and registered at Lloyds as a 100 A1 Class sea-going dredger.

Dimensions of hull, 110ft. by 44ft. by 12ft.
Maximum dredging depth, 35ft.

The Dredger has recently completed important dredging operations in connection with harbour improvements for the Government of the Bahamas. The Dredger has recently been dry-docked and thoroughly overhauled and passed by Lloyds' Surveyors prior to selling. She is a sound, reliable, and economic machine, admirably suited for digging channels or deepening harbours.

For further particulars apply to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1 (quoting "W/Bahamas 875"), or the COLONIAL SECRETARY, Nassau, N.P., Bahamas. 8632

PUBLIC NOTICES

Applications are Invited for the following PROFESSORSHIPS at the College of Engineering, Guindy, Madras:—
PROFESSOR of CIVIL ENGINEERING.
PROFESSOR of MECHANICAL ENGINEERING.
PROFESSOR of ELECTRICAL ENGINEERING.

Candidates should not be more than 40 years of age. They must hold an Honours Degree in Engineering and have had practical experience in the branch of engineering concerned.

Salary Rs. 1000 a month, rising by annual increments of Rs. 50 a month to Rs. 1500. Possibility of special allowance in addition to salary for candidates with exceptional qualifications. Appointment on agreement for five years in first instance with possibility of extension. Free first-class passage to India for candidate and family. Strict medical examination.

Further particulars and forms of application may be obtained upon request by postcard to the SECRETARY to the HIGH COMMISSIONER FOR INDIA, 42, Grosvenor-gardens, London, S.W. 1. Applicants should state for which post they require particulars.

Last date for receipt of applications 23rd June, 1928. 8652

Assistant Engineers Required for the RAILWAY DEPARTMENT of NIGERIA for a tour of 12 to 18 months' service, with prospect of extension. Salary £480, rising to £920 a year. Outfit allowance of £60 on first appointment. Free quarters and passages, liberal leave on full salary. Candidates, aged 23 to 35, should either possess an Engineering Degree of a recognised University or should have passed Sections "A" and "B" of the Associate Membership Examination of the Institution of Civil Engineers. They should also have had three or four years' regular training as a Civil Engineer, preferably on Railway Works.—Apply at once by letter, stating age, particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/15394. 8711

Computers, Class II., REQUIRED for Ordnance Committee, Royal Arsenal, Woolwich, S.E. 18. Mathematical qualifications equivalent London University Intermediate Examination. Age 21-35 (service H.M. Forces may be deducted). Commencing salary (including bonus): males, £193; females, £166. Preference to ex-Service candidates.—Apply, SECRETARY, above address, not later than 16th June. 8677

PUBLIC NOTICES

Armourers and Brasiers' Company.

LECTURES IN METALLURGY.

The Company have arranged for the following Lectures to be delivered:—

At the ROYAL SCHOOL of MINES, Prince Consort-road, South Kensington, at 5.15 p.m. on 4th, 11th, and 18th June, 1928, by
GEORGE MORTIMER, Esq.,
on
"THE FOUNDING OF ALUMINIUM AND ITS LIGHT ALLOYS."

At the BATTERSEA POLYTECHNIC, Battersea Park-road, S.W., at 7 p.m. on 5th, 12th, and 19th June, 1928, by
Dr. J. M. ROBERTSON, B.Sc., Ph.D., A.R.T.C.,
on
"THE HEAT TREATMENT OF STEEL."

Admission free, without ticket. 8585

Ipswich Education Committee.

SCHOOL OF ENGINEERING.

GRADUATE in ENGINEERING WANTED, with teaching experience, to commence duties in September next. The person appointed will be employed full time, partly with engineering classes in the day-time for apprentices preparing for the National Certificates in Mechanical Engineering, and partly in evening teaching at the School of Engineering, as may be required. Salary in accordance with the Burnham Scale for Teachers in Technical Schools. Form of application, which should be returned not later than the 22nd June, will be forwarded on receipt of a stamped addressed envelope.

H. ARMITAGE,
Secretary for Education.
Tower House, Ipswich. 4606

The University of Liverpool.

FACULTY OF ENGINEERING.

The Faculty of Engineering invites APPLICATIONS for a MUNITIONS COMMITTEE RESEARCH FELLOWSHIP, tenable for two years. The value of the Fellowship is £250 for the first year and £350 for the second year.

Applications, with an outline of the research contemplated, should be forwarded to the DEAN of the FACULTY before June 25th. 8667

PUBLIC NOTICES

The Institution of Structural Engineers.

EXAMINATIONS FOR GRADUATESHIP AND ASSOCIATE-MEMBERSHIP.

The next Examinations will be held on Wednesday (Graduateship), Thursday and Friday (Associate-Membership), 4th, 5th and 6th July. Closing date for entries, Wednesday, 27th June. The Examination will be held in London, Loughborough (Leicester), Bombay and such other centres as may be arranged. Syllabus and full particulars on application to the undersigned.

MAURICE G. KIDDY, F.I.S.A.,
Secretary.
10, Upper Belgrave-street, S.W. 1,
31st May, 1928. 8657

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.
Principal:
B. MOUAT JONES, D.S.O., M.A. (Oxon).
UNIVERSITY OF MANCHESTER (FACULTY OF TECHNOLOGY).

DEGREE COURSES IN TECHNOLOGY.

The Prospectus gives particulars of the courses leading to the Manchester University Degrees (B.Sc. Tech., M.Sc. Tech., and Ph.D.) and Certificates in the Faculty of Technology, in the following Departments:—

MECHANICAL ENGINEERING
(Prof. Dempster Smith, M.B.E., M.Sc. Tech., M.I.M.E.).
ELECTRICAL ENGINEERING
(Prof. Miles Walker, M.A., D.Sc., M.I.E.E.).
MUNICIPAL AND SANITARY ENGINEERING.
(G. S. Coleman, D.Sc. Eng., A.M. Inst. C.E., A.M. Inst. M. and Cy. E., F.R. San. I.).
APPLIED CHEMISTRY, including General Chemical Technology, Chemistry of Textiles (Bleaching, Dyeing, Printing and Finishing), Paper Manufacture, Metallurgy and Assaying, Chemical Technology of Brewing, Electro-Chemistry, Photography, Colouring Matters, Foodstuffs and Fuels
(Prof. James Kenner, D.Sc., Ph.D., F.R.S.).
TEXTILE TECHNOLOGY
(Prof. W. E. Morton, M.Sc. Tech.).
INDUSTRIAL ADMINISTRATION (Post-Graduate Course)
(J. A. Bowie, M.A., D.Litt.).

Prospectus will be forwarded free on application to the REGISTRAR, College of Technology, Manchester. 8665

Administrative County of London.

PAINTING WORKS.

The London County Council invites TENDERS for the CLEANING, REPAINTING, &c., of:—

1. HAMMERSMITH BRIDGE;
2. VAUXHALL BRIDGE;
3. GREAT EASTERN-STREET RAILWAY BRIDGE; BRIDGE over Waterworks Branch of River Lee; STANLEY BRIDGE, King's-road, Fulham; and LEE BRIDGE, over the River Lee;
4. BRIDGE over East London Railway (at Rotherhithe Tunnel and Woolwich Tunnel);
5. EIGHT SMALL BRIDGES in the Metropolitan Area.

Persons desiring to submit Tenders for all or any of these works may obtain the specifications, bills of quantities, forms of Tender and contract, &c., on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £1 by cheque or draft to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the works may be obtained on personal application, and the contract documents may be inspected before payment of the fee.

Correspondence and remittances by post should be addressed to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1, or, if personal application is made, applicants should apply in Room 3A at No. 3, Warwick House-street, Cockspur-street, S.W. 1.

The contractors will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in the "London County Council Gazette."

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 2nd July, 1928, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX,
8709 Clerk of the London County Council.

Bombay, Baroda and Central INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 29th June, TENDERS for the SUPPLY of:
1. LOCOMOTIVE BOILERS;
and up to Noon on Friday, 22nd June, TENDERS for the SUPPLY of:—
2. DOG SPIKES.

Tenders must be made on forms, copies of which with specification can be obtained at these offices on payment of 20s. each for No. 1 and 10s. each for No. 2 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.
Offices: The White Mansion, 91, Petty France, Westminster, S.W. 1.
6th June, 1928. 8713

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PUBLIC NOTICES

Battersea Borough Council.

PROPOSED "SOUTHLANDS" PUBLIC WASH-HOUSE.

CAST IRON WASHING COMPARTMENTS.

The Council invite TENDERS for the SUPPLY of CAST IRON DIVISIONS and RETURN ENDS for 52 Washing Compartments, together with GALVANISED CAST IRON WASHING and BOILING TROUGHS.

Forms of Tender, containing full particulars, may be obtained at the Town Hall, Lavender-hill, S.W. 11, between 10 a.m. and 4 p.m. (Saturday, 10 a.m. and 1 p.m.).

Tenders, sealed and marked on the outside "Tender for Washing Compartments," must be delivered to me by 10 a.m. on Wednesday, 20th June, 1928.

The Council do not bind themselves to accept the lowest or any Tender, and they reserve to themselves the right to accept the whole or any portion of a Tender.

EDWIN AUSTIN,
Town Clerk.

Town Hall, Battersea, S.W. 11,
31st May, 1928. 8651

Bengal-Nagpur Railway Company, LIMITED.

The Directors are prepared to receive TENDERS for :—

(A) 8 DECK SPAN GIRDER BRIDGES (150ft. Span).

(B) 10 PLATE GIRDER BRIDGES (40ft. Span).

Specifications and forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad-street, London, E.C. 2, on or after 7th June, 1928.

A fee of 20s. will be charged for each copy of Specification (A) and of 10s. for each copy of Specification (B), which is NOT returnable.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board,
R. C. VOLKERS,
Secretary.

7th June, 1928. 8712

Birmingham Union.

WESTERN-ROAD HOUSE.

TO HEATING CONTRACTORS, ELECTRICAL CONTRACTORS.

TENDERS are INVITED for the following WORKS, in accordance with plans and specification prepared by Messrs. Henry Lea and Son, Consulting Engineers, of Edmund-street, Birmingham, viz.:—

ENGINEERING WORK, embodying (A) Calorifiers and Pumps, (B) Heating Installation, (C) Domestic Hot Water Supply, (D) Cold Water Supply, (E) Steam and Condense, (F) the requisite Mains for same.

ELECTRICAL WORK.—A Small Amount of Electric Lighting Work which is involved in the modernisation of the two blocks.

Firms desirous of tendering should send their names to me, accompanied by a deposit of £5 5s., if applying for the engineering work, specification, &c., and £2 2s. if for the electrical work, not later than 11 a.m. on Monday, the 11th June. Cheques should be made payable to "The Treasurer," Birmingham Union. The amount so deposited will be refunded by the Guardians' cheque on receipt of a bona fide Tender, which must be received by me not later than 10 a.m. on Thursday, the 28th June, sealed and endorsed "Western-road House. Tender for Engineering Work," or "Western-road House, Tender for Electrical Work," as the case may be.

The successful contractor will be required to give security for an amount to be fixed by the Guardians; also to enter into an agreement to pay during the execution of the contract to the whole of the workpeople engaged upon the work not less than the trade union or standard rate of wages, to observe the hours and conditions of labour recognised by the Employers' and Workers' Associations, to absolve the Guardians from liability relating to compensation to workpeople, &c. &c. A copy of the form of agreement and conditions to be embodied therein may be inspected at these offices.

The Guardians will give preference—save in exceptional circumstances—to contractors who have adopted the Government's scheme for finding employment for disabled ex-Service men (King's National Roll) and are fulfilling its conditions.

The Guardians do not bind themselves to accept the lowest or any Tender.

C. P. BEECH,
Clerk to the Guardians.

Union Offices,
Edmund-street, Birmingham,
5th June, 1928. 8680

Borough of Stockton-on-Tees.

TO STEEL BUILDING CONSTRUCTORS.

OMNIBUS GARAGE.

The Omnibus Committee is prepared to receive TENDERS with complete DESIGNS and SPECIFICATION for the SUPPLY and ERECTION of STEEL-FRAME WORK and ROOF in connection with a structure in Bridge-road for garage purposes.

Plan of the site, together with outline specification and general particulars, may be obtained on application to Mr. J. P. Wakeford, M. Inst. C.E., Borough Engineer, Victoria Buildings, Stockton-on-Tees.

Tenders, &c., endorsed "Omnibus Garage," must be delivered to the undersigned not later than the 29th day of June, 1928, and the Corporation do not undertake to pay any expenses in connection therewith.

The lowest or any Tender will not necessarily be accepted, but each contractor must understand that any accepted quotation may be included as a provisional sum in the builder's contract for the erection of the entire structure.

THOS. DOWNEY,
Town Clerk.

Borough Hall, Stockton-on-Tees,
8th June, 1928. 8708

County Council of the County of Argyll.

NEW TYNDRUM-BALLACHULISH ROAD.
CONTRACT NO. 1.
CARNOCH TO KINGSHOUSE SECTION,
12¼ Miles.

CLEARING, FENCING, DRAINAGE, EARTHWORKS, BRIDGES, CULVERT, RETAINING WALLS, CARRIAGEWAY, AND OTHER WORKS.

The Council are prepared to receive TENDERS from experienced Public Works Contractors of good standing for the CONSTRUCTION of the FIRST SECTION of the NEW TYNDRUM-BALLACHULISH ROAD, from Carnoch through Glencoe, to the vicinity of Kingshouse. The work upon this Section involves a considerable amount of excavation in rock and for watercourses, together with the Construction of Reinforced Concrete Bridges, Culverts, &c.

Drawings and specifications may be seen on and after 4th June, 1928, at the offices of :—The Chief Engineer, Ballachulish East, Argyll; the Ministry of Transport, 122, George-street, Edinburgh; the Ministry of Transport (Roads Department), 7, Whitehall-gardens, London, S.W. 1.

Specification, bill of quantities, form of Tender, and full information may be obtained, on and after the same date, at the office of the Chief Engineer, Mr. James M'Gregor, D.S.O., M. Inst. C.E., Ballachulish East, Argyll, on depositing £3 3s., which deposit will only be returned on receipt of a bona fide Tender and the return of all the documents. Cheques should be made payable to the County Council of Argyll.

A conveyance will be provided, and an engineer will meet contractors at Ballachulish Railway Station, at 2.35 p.m., on 12th June, 1928, to show them over the route.

Sealed Tenders, endorsed "Tender, New Tyndrum-Ballachulish Road, Contract No. 1," must be lodged with the undersigned not later than 2nd July, 1928.

The Council do not bind themselves to accept the lowest or any Tender, and, in view of the special character of the work, regard will be had to the standing and experience of the several contractors tendering.

M. SINCLAIR,
County Clerk.

County Offices,
Lochgilphead, Argyll,
30th May, 1928. 8661

PUBLIC NOTICES

Borough of Newbury.

BORING WORKS AT WATER PUMPING STATION.

The Newbury Corporation invite TENDERS for the EXECUTION of WORKS at the Corporation's Water Pumping Station at Speen Newbury, including :—

(A) Construction of Dumb Well ;
(B) Sinking and Lining Bore-hole to a depth between 100ft. and 200ft.

Copies of the specification and form of Tender may be obtained on application to the Water Engineer and Manager at No. 18, Cheap-street, Newbury.

Tenders must reach the undersigned in an envelope endorsed "Tender, Waterworks," not later than Twelve Noon on Tuesday, the 19th June.

The Corporation do not bind themselves to accept the lowest or any Tender.

S. WIDDICOMBE,
Town Clerk.

Municipal Buildings, Newbury,
7th June, 1928. 8675

Edinburgh Corporation—Electric Department.

PORTOBELLO ELECTRICITY SUPPLY STATION.
TO CONTRACTORS.

The Magistrates and Council are prepared to receive TENDERS for the WORK to be done in constructing at Portobello, Edinburgh, a TUNNEL about 500 yards long under the foreshore and sea bed of the Firth of Forth, together with a SHAFT on the land and a SHAFT in the sea.

Plans may be seen and copies of the specification and schedule obtained by contractors having experience of the kind of work indicated upon application to the Engineers, Messrs. J. and A. Leslie and Reid, C.E., 72a, George-street, Edinburgh, and upon payment of £1, which will be returned to all who send in a bona fide Tender.

Tenders, endorsed "Tender for Sea Water Tunnel, Portobello," must be lodged with the Subscriber not later than Friday morning, 22nd June, 1928.

The Magistrates and Council do not bind themselves to accept the lowest or any Tender.

A. GRIERSON,
Town Clerk.

City Chambers, Edinburgh,
1st June, 1928. 8666

Edmonton Union.

PROVISION OF FIRE ESCAPE STAIRS.

The Guardians invite TENDERS for the SUPPLY and FIXING of IRON FIRE ESCAPE STAIRS at Edgebury House, Woburn Sands, near Bletchley.

Forms of Tender, upon which only Tenders will be received, may be obtained on application to me, accompanied by a stamped addressed foolscap envelope.

Sealed Tenders, endorsed "Tender for Fire Escape Stairs," must reach me by 9 a.m. on Friday, the 22nd June, 1928.

By Order,
E. RIDLEY,
Clerk to the Guardians.

Board Room,
77, Bridport-road, Edmonton. 8658

Metropolitan Water Board.

TENDERS FOR THE SUPPLY AND ERECTION OF PUMPING MACHINERY AT THE HOE-LANE PUMPING STATION, GOAT-LANE, ENFIELD, MIDDLESEX.

The Metropolitan Water Board invite TENDERS for the SUPPLY and ERECTION of ONE HEAVY FUEL OIL HIGH-COMPRESSION ENGINE and CENTRIFUGAL PUMP, PIPING, &c., at their Hoe-lane Pumping Station, Goat-lane, Enfield, Middlesex.

Forms of Tender, conditions of contract, specification and drawings may be inspected without payment of a fee at the offices of the Board, Chief Engineer's Department (Room 173), on and after Tuesday, 12th June, 1928.

Contractors desirous of tendering may obtain the necessary documents from the Chief Engineer on production of an official receipt for the sum of One Guinea, which must be deposited with the Accountant to the Board and which will be returned on receipt of a bona fide Tender accompanied by all the abovenamed documents and drawings. Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Oil Engine and Pump, Hoe-lane," must be delivered at the offices of the Board (Room 122) not later than 10 a.m. on Friday, 29th June, 1928.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
4th June, 1928. 8672

Metropolitan Water Board.

TENDERS FOR THE SUPPLY AND ERECTION OF PUMPING MACHINERY AT THE CHESHUNT PUMPING STATION, BROOKFIELD-ROAD, CHESHUNT, HERTFORDSHIRE.

The Metropolitan Water Board invite TENDERS for the SUPPLY and ERECTION of TWO SETS of HEAVY FUEL OIL HIGH-COMPRESSION ENGINES and CENTRIFUGAL PUMPS, PIPING, &c., at their Cheshunt Pumping Station, Brookfield-road, Cheshunt, Hertfordshire.

Forms of Tender, conditions of contract, specification and drawings may be inspected without payment of a fee at the offices of the Board, Chief Engineer's Department (Room 173), on and after Tuesday, 12th June, 1928.

Contractors desirous of tendering may obtain the necessary documents from the Chief Engineer on production of an official receipt for the sum of One Guinea, which must be deposited with the Accountant to the Board and which will be returned on receipt of a bona fide Tender accompanied by all the abovenamed documents and drawings. Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board, and endorsed "Tender for Oil Engines and Pumps, Cheshunt," must be delivered at the offices of the Board (Room 122) not later than 10 a.m. on Friday, 29th June, 1928.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
4th June, 1928. 8673

South Indian Railway Company, LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

1. SHEFFIELD TOOLS, &c.
2. GALVD. CORRUGATED SHEETS.
3. CARRIAGE FITTINGS.
4. IRON CHAINS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Sheffield Tools, &c." or as the case may be, must be left with the undersigned not later than 12 Noon on Friday, the 22nd June, 1928.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the specifications Nos. 1, 2, and 3, and of 2s. 6d. for each copy of the Specification No. 4.

Copies of the drawings may be obtained at the Offices of Messrs. Robert White and Partners, the Company's Consulting Engineers, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France,
Westminster, S.W. 1.
8th June, 1928 8724

PUBLIC NOTICES

Wandsworth Union.

The Guardians of the above-named Union are prepared to invite TENDERS for the RE ORGANISATION of the ENGINEERING PLANT at their Swaffield-road Institution.

Firms wishing to Tender for Laundry Plant, Central Heating Plant, Electric Lighting Plant and Wiring the Institution, Water Softener Plant, &c., in separate sections, to the plans and specifications now being prepared by the Guardians' Consulting Engineer, Mr. W. M. Binny, A.M.I.C.E., are requested to send their names to the Clerk with reference to similar recent work carried out by them at other Institutions.

Firms are requested in the first instance to examine at the Guardians' offices a block plan showing the proposed extent of the work, after which a set of plans and specifications, when ready, will be provided to the firms selected to Tender, a deposit of £10 being required, which will be returned on receipt of a Tender properly filled in.

Applications to be allowed to Tender must be received not later than 20th June, 1928.

By Order,
H. PHILLIPS,
Clerk to the Guardians.

Union Offices,
St. John's-hill, Wandsworth, S.W. 18,
4th June, 1928. 8670

Egyptian Ministry of Education.

The Egyptian Ministry of Education invite APPLICATIONS for the POST of :—

PROFESSOR OF ELECTRICAL ENGINEERING.

The applicant must have at least the M.Sc. Degree in Electrical Engineering and must have had practical and teaching experience.

The salary will be £E900 to £E1360 (approximately £922 to £1394) a year, according to qualifications, and the appointment will be on contract for three years. The contract may be renewed at the end of that period if agreeable to both parties. One month's salary will be paid on arrival for travelling expenses.

Applications should be sent to the DIRECTOR, Egyptian Education Office, 30, Victoria-street, London, S.W. 1, so as to be received not later than June 14th.

Applicants should give their age, academic qualifications, previous experience, and other particulars as they think fit, and should give the names of not more than three persons to whom reference may be made. 8649

Hartlepool Port and Harbour Commission.

ENGINEER, SECRETARY, and HARBOUR MASTER (One Post) REQUIRED IMMEDIATELY. Salary £400-£500 per annum, according to experience. Candidates, who must be Associate Members of the Inst. C.E., must have had at least 5 years' practical experience of Dock and Harbour Works. Applications, enclosing statement of qualifications, age, war service, &c., and copies of three recent testimonials, must be received before June 20th.

J. D. HOWKINS,
Secretary.

Hartlepool Port and Harbour Commission,
30, Town Wall, Hartlepool. 8701

Metropolitan Borough of Greenwich.

APPOINTMENT OF BATHS SUPERINTENDENT.

The Council of the Metropolitan Borough of Greenwich is prepared to receive APPLICATIONS for the APPOINTMENT of a SUPERINTENDENT ENGINEER at the Public Baths and Wash-houses, Trafalgar-road, Greenwich.

The inclusive salary will commence at the rate of £400 per annum, rising by three annual increments of £20, £20 and £10 respectively to a maximum of £450 per annum, with residence, fuel and light.

The appointment will be subject to the provisions of the Council's Superannuation Act.

Applicants must be duly qualified engineers and have had experience in Electrical Plant and in the management of a Public Baths Establishment.

Applications must be in the handwriting of the applicants on forms to be obtained from the undersigned and must be accompanied by copies of not more than three recent testimonials, such applications to be sealed and endorsed "Baths Superintendent," and must be received here not later than 10 a.m. on Monday, the 18th June, 1928.

The appointment will be terminable by one month's notice in writing on either side. Canvassing members of the Council, either directly or indirectly, will be a disqualification.

Stamped, addressed foolscap envelope must accompany application for form.

FREDERICK J. SIMPSON,
Town Clerk.

The Town Hall,
Greenwich-road, S.E. 10,
24th May, 1928. 8608

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO APPLICANTS FOR DRAUGHTSMAN'S SITUATION, BOX P4535.—The ADVERTISER wishes to THANK all APPLICANTS and to inform them that the POST has now been satisfactorily FILLED. 8706 A

WANTED, TWO ENGINEERS for Abroad, Not over 25 to 28 years of age and single. A good knowledge of Mechanical Refrigeration on the Ammonia system necessary, applicants to give full particulars of their experience.—Write, "K.," Box 747, T. B. Browne's Advertising Offices, 163, Queen Victoria-street, London, E.C. 4. 8716 A

ASSISTANT ENGINEER REQD. Technical, Practical experience Water-tube Boilers and Distilling Processes. Knowledge of German. Age 30-40. Salary £600 p.a.—Apply, LESLIE and CO., Employment Specialists, Empire House, St. Martin's-le-Grand, E.C. 1. No preliminary fee. P4584 A

EXPERIENCED TRAVELLER in the Iron and Steel Trade, with a knowledge of and connection in Pig Iron, Steel Plates, Sections and Joists, to travel London and Home Counties, South Coast and South-Eastern Counties.—Reply, stating age, experience, salary, and commission required, and give copies of recent testimonials, to Box T. 1340, c/o Dawson's, 118, Cannon-street, E.C. 4. 8671 A

HEATING ENGINEER in Large Contractor's Office, Midland district, REQUIRED. Must be first-class man, capable of taking charge if necessary. No one who has received less than £350 a year need apply. Details of experience, age, salary required.—Address, 8710, The Engineer Office. 8710 A

MILL ENGINEER REQD., London. Must have experience Wallpaper Factory. Good tech. training. £400 p.a., with prospects.—Apply, LAURIE and CO., Employment Specialists, 28, Basinghall-street, E.C. 2. No preliminary fee. P4585 A

RATE-FIXER REQUIRED for North-East Coast Firm manufacturing varying products.—Address, stating age, full particulars of experience, salary required, with testimonials, P4604, The Engineer Office. P4604 A

REQUIRED by London Firm of Refrigerating Engineers, TWO trained REFRIGERATING ENGINEERS, thoroughly capable of preparing estimates, tenders, and correspondence for Refrigerating Plant, both automatic and non-automatic. Give age, experience, and salary.—Address, 8668, The Engineer Office. 8668 A

TECHNICAL SALES REPRESENTATIVE REQUIRED. One for East Midlands and one for S. Wales and West of England. Preferably having experience in applications of Anti-friction Bearings.—Full particulars to Box D, 3, Old Jewry, London, E.C. 2. 8699 A

TRAMWAY ENGINEER REQUIRED for Important British-owned Company abroad. Must have electrical experience and a first-hand practical and expert knowledge of all technical details of operating, particularly Rolling Stock and Workshops, including also Steam Power Generation. Initiative and energy essential. State qualifications, experience, &c.—Write, "TRAMWAY," c/o Street's, 6, Gracechurch-street, E.C. 3. 8659 A

SITUATIONS OPEN (continued)

YOUNG ENGINEER WANTED for Large Food Factory in North of England; experimental and factory development work. University graduate preferred.—Address, stating age, qualifications, experience, and salary required, 8656, The Engineer Office. 8656 A

WORKS MANAGER REQUIRED for Factory Producing Moulded Articles from Plastic Material. Must be well experienced in Hydraulic Presses and Plant. Capable of supervising complete organisation and attaining maximum output. Some knowledge of Chemistry and Dyeing an advantage. Commencing salary £400.—Address in confidence, P4580, The Engineer Office. P4580 A

WANTED, CENTRIFUGAL and TURBINE PUMP DESIGNER and DRAUGHTSMAN, capable of producing efficient High and Low-lift Pumps at competitive prices with modern equipment. State experience and salary required.—Address, 8448, The Engineer Office. 8448 A

WANTED, DRAUGHTSMAN for Cement, Temporary. London district.—Address, P4587, The Engineer Office. P4587 A

WANTED, Fully Experienced DRAUGHTSMAN, thoroughly accustomed to Iron and Steel Works practice and Plant. None but first-class men should apply. State experience, age, and salary.—Address, 8674, The Engineer Office. 8674 A

WANTED IMMEDIATELY, DRAUGHTSMAN, accustomed to the designing of Pneumatic Drills and Hammers.—Address, giving experience, names of previous employers, and salary required, 8625, The Engineer Office. 8625 A

WANTED, SIX Live DRAUGHTSMEN, Accustomed to the design of Water-tube Boilers, Superheaters, Economisers, &c., who are required to commence work immediately on important contracts. Persons without above training will not be considered.—Address in first instance, 8539, The Engineer Office, stating salary, age and past experience, also earliest date when duties could be commenced. 8539 A

A CONSTRUCTIONAL STEEL WORK DRAUGHTSMAN REQ. in London; must be able to design, &c. Only those with good experience need apply. State age, salary and experience.—Address, 8721, The Engineer Office. 8721 A

DRAUGHTSMAN and DESIGNER, Specialising in Lattice Tower Work, with practical experience, WANTED in West of England.—Address, stating age and qualifications and salary required, P4603, The Engineer Office. P4603 A

DRAUGHTSMAN REQUIRED, Experienced in Electric Crane Design and Details. Accustomed to taking out quantities for estimating.—Address, P4591, The Engineer Office, stating age, experience, salary. P4591 A

DRAUGHTSMAN REQUIRED (North-East Coast), with first-class experience in Water-tube Boiler Design and Details, for land and marine work. Applicants must give full details of past experience, stating age and salary expected and when able to commence.—Address, 8702, The Engineer Office. 8702 A

DRAUGHTSMAN REQUIRED, to Take Charge of Production Drawings in works employing about 700 hands, making very accurate machinery. Progressive position for a young man with plenty of energy. Only those who have had workshop experience will be considered.—Address, stating age, experience, and salary required, 8600, The Engineer Office. 8600 A

DRAUGHTSMAN REQUIRED with First-class practical and theoretical training and with considerable experience in the design and installation of plant for a large engineering factory. Applicants must give full details of experience and training and enclose copies of recent testimonials, and should state age, salary required, and when at liberty to start.—Address, 8605, The Engineer Office. 8605 A

DRAUGHTSMAN WANTED, Experienced in Structural and Mechanical Work in connection with Coal-handling Plants. Experienced men only need apply. State age, experience, and salary required.—Address, 8643, The Engineer Office. 8643 A

DRAUGHTSMAN, with First-class Experience of Steam Turbine design and Detail Work, for works in Midlands. State age, salary, experience, and when able to commence.—Address, 8631, The Engineer Office. 8631 A

DRAUGHTSMAN With General Experience WANTED for South of England. State age, experience, and wages.—Address, 8725, The Engineer Office. 8725 A

JUNIOR DRAUGHTSMAN REQUIRED in London, with Boiler, Pressure Vessel, Tank and General Plate Work experience (estimating experience an advantage). Must be able to take own particulars from site. State age, salary, and previous experience.—Address, 8722, The Engineer Office. 8722 A

JUNIOR DRAUGHTSMAN WANTED, Accustomed to Conveyors and Structural Work. Shop experience essential.—Address, stating age, experience, and salary, 8717, The Engineer Office. 8717 A

MATERIALS HANDLING PLANT DRAUGHTSMAN REQUIRED, fully experienced in the preparation of Schemes, Lay-outs, and Designs.—Applications, giving full details of experience, age, salary required, and endorsed "Conveyor Draughtsman," should be addressed to the CHIEF ENGINEER, The Gas Light and Coke Company, Horseferry-road, S.W. 1. 8653 A

REINFORCED CONCRETE DRAUGHTSMAN REQUIRED, able to prepare Architectural Schemes and experienced in detailing working drawings.—Applications, giving full details of experience, age, salary required, and endorsed "Concrete Draughtsman," should be addressed to the CHIEF ENGINEER, The Gas Light and Coke Company, Horseferry-road, S.W. 1. 8723 A

STRUCTURAL DRAUGHTSMEN, Accustomed to designing and estimating for Structural Steel Work, REQUIRED for London office. State age, experience, and salary required.—Write, Box 732, Dorland's, 14, Regent-street, S.W. 1. P4582 A

WANTED, Energetic Young ENGINEER to Act as FOREMAN in General Engineering and Boiler Works near London. Must be capable of handling labour and economically progressing work through shops. State age, wages, and give full particulars of experience.—Address, 8676, The Engineer Office. 8676 A

ENGINEER FOREMAN ERECTOR REQUIRED for Cement Works Reconstruction.

Must have had previous experience in erection of Elevators, Conveyors, &c.

Apply, stating age and salary required, to ASSOCIATED PORTLAND CEMENT MANUFACTURERS, Ltd., Whites Works, Swanscombe, Greenhithe, Kent. 8664 A

SITUATIONS WANTED

ADVERTISER (26), Unmarried, Public School, thorough training eng. and electrical stores, intimate knowledge of India, fluent speaker Hindustani, Bengali, DESIRES POSITION in India.—Address, P4593, The Engineer Office. P4593 B

ADVERTISER (32) SEEKS RESPONSIBLE POSITION at home or abroad; charge of plant on contracts, steam and oil engines, marine and dockyard experience.—Address, P4581, The Engineer Office. P4581 B

ADVERTISER (42) DESIRES POSITION, Works Manager or Chief Engineer, works or factory; excellent references, ability; M.I. Mech. E.—Address, P4596, The Engineer Office. P4596 B

For continuation of Small Advertisements see page 3.

A Seven-Day Journal

The Singapore Floating Dock.

PREPARATIONS are well advanced for the towage to Singapore of the great floating dock, which was built by Swan, Hunter and Wigham-Richardson, at Wallsend, and the voyage is expected to begin during the present month. Insurances to the value of £900,000 have been effected to cover the risks of the tow, which will be the most important undertaking of the kind that has ever been attempted. The dock consists of seven sections, and it is intended that they shall be towed out in two groups—four sections being in the first group and three sections in the second. Each group is to be in charge of four powerful tugs, supplied by L. Smit and Co., of Rotterdam, a firm that has specialised in the towage of heavy vessels and structures over long distances. The voyage will be one of approximately 8500 miles. It will include the passage of the Suez Canal, for which special arrangements have been made. In order to avoid undue interference with normal traffic the two groups of dock sections are to be towed through the Canal at the same time. Although the distance is only 100 miles, the passage is expected to take four days. On the first night the convoy is to lie up in a "bay" which has been specially excavated midway between Port Said and Ismailia, the two succeeding nights being spent in Lake Timsah and the Grand Lake respectively. No difficulty is anticipated in passing the dock through the Canal, though the operation will necessarily call for extreme care. The first group of sections will be 465ft. in length, 172ft. in width, and draw about 7ft. The second group will be 390ft. in length, 172ft. in width, and draw about 8ft. The total height in each case will be 75ft., and it is mainly because of the great area thus presented to the wind that a certain element of risk enters into the forthcoming towage operation.

The Astronomer Royal's Report.

IT has frequently been suggested that the latitude and longitude of a point on the earth's surface may not be absolutely constant, and that for reasons not difficult to suggest, it may be subject to a secular change. Tests to discover any such change have recently been made, but so far as Greenwich is concerned, the Astronomer Royal's report to the Board of Visitors at their annual visitation on Saturday of last week, June 2nd, seems to dispel the possibility of a secular change in the latitude of the observatory of appreciable amount during the past seventy-five years. The observations made on four stars near the pole from 1851 onwards have been compared. Averaged over periods of fifteen years these observations give values for the latitude of Greenwich which agree with one another to within a fifth of a second of arc. The least average value for the latitude of Greenwich given by these observations is 51° 28′ 38″·02 and the greatest 51° 28′ 38″·19. Were this difference acceptable as completely genuine it would imply that the observatory between the years 1866 and 1895 had moved about 17ft. nearer the North Pole. It still remains a possibility that the longitude is subject to a secular variation. If there is a change at all it is in longitude rather than in latitude that we would expect to find it, but it is much more difficult to examine the existence of such a change than that of a change in latitude. Sir Frank Dyson's report also contains a passage of metallurgical interest. Observation of the time-keeping of the standard sidereal clock, the pendulum rod of which is made of invar, a 35 per cent. nickel-iron alloy, reveals the fact that the clock rate is subject to a progressive increase amounting to 0·011 seconds per day per month. This change can be accounted for by an increase in the length of the pendulum which, it is calculated, is lengthening at the rate of one micron—0·001 mm.—in 118 days. The clock also shows a temperature inequality amounting to about 1 second per year for 1 deg. Fah. change of temperature.

The Retirement of Sir Robert Dixon.

AT the beginning of June, Engineer Vice-Admiral Sir Robert B. Dixon, K.C.B., D.Eng., retired from the office of Engineer-in-Chief of the Fleet, which he has filled with great ability since his appointment in 1922. As recorded in our Journal note of February 17th, he has been succeeded by Engineer Rear-Admiral Reginald W. Skelton, C.B., C.B.E., D.S.O. Sir Robert entered the Navy as assistant engineer in July, 1888, and then spent three years at the Royal Naval College, Greenwich, after which he saw service as engineer-lieutenant in H.M.S. "Hecla" and H.M.S. "Trafalgar." In 1893 he returned to Greenwich, where he spent three years as instructor in applied mechanics. After service on H.M.S. "Victorious" and H.M.S. "Centurion" in China, he returned to the Engineer-in-Chief's Department at the Admiralty in 1898. The following year he was appointed to Chatham and had charge of the drawing-office, and in 1900 was appointed as second assistant under the chief engineer. In May, 1902, he went to Portsmouth as first assistant to the Chief Engineer, which position he held for two years, and was then transferred to the Director of Dockyards Department at the Admiralty. As Engineer-Commander he joined H.M.S. "Dominion" of the Channel Fleet in February, 1907, and became chief engineer at Haulbowline Dockyard in 1909. Three years later he returned to the Admiralty, and received special recognition for his work on an inquiry into the education and training of cadets. The same year he became manager of the Engineering Department at Portsmouth Dockyard. In 1915 he was appointed engineer-captain. In 1917 he returned to the Admiralty as assistant to the Director of Dockyards, and two years later became assistant to the Engineer-in-Chief. He was made Engineer Rear-Admiral in December, 1919, and became Deputy Engineer-in-Chief in the June of the following year. Two years later he was appointed Engineer Vice-Admiral and began his work as Engineer-in-Chief of the Fleet. In recognition of the services which he rendered during the war he was awarded C.B. (Civil) at the end of 1917, and in January, 1924, he was appointed to be K.C.B. The honorary degree of D. Eng. was conferred upon him by the University of Sheffield in 1926. He was responsible for the developments in the machinery designs of the new battleships "Nelson" and "Rodney," and the "Kent" class cruisers.

The Birthday Honours.

IN the lengthy list of honours bestowed on the occasion of the King's birthday several names appear which are of interest to the engineering profession. A barony has been conferred upon Sir George Rowland Blades, the President of the Federation of British Industries and a director of the Southern Railway. Among those to be created Knights Bachelor we note the names of Mr. W. B. Clode, President of the Railway Rates Tribunal; Mr. Archibald Hurd, the naval writer; Dr. J. H. Jeans, secretary of the Royal Society; Mr. G. C. Vyle, President of the Association of British Chambers of Commerce; Mr. H. Walker, chief inspector of mines; Captain E. J. Headlam, director of the Royal Indian Marine; and Mr. C. L. N. Felling, general manager, Kenya and Uganda Railways. A Companionship of Honour has been conferred upon Professor J. S. Haldane, director of the Mining Research Laboratory, Birmingham University. Sir John Dewrance and Sir Henry Maybury have been made Knights Grand Cross of the British Empire, and Colonel E. H. Hiley, of the Rhodesian Railway Commission, has been made a Knight of the same Order. Among those to be created Commanders of the Order of the British Empire, are Mr. W. H. Carter, assistant director of Naval Construction, Admiralty; Dr. C. H. Lander, director of Fuel Research; Mr. J. Quirey, vice-president for finance, L.M.S. Railway; and Mr. H. E. Wimperis, director of Scientific Research, Air Ministry. Mr. D. N. Dunlop, director of the Beama; Mr. H. O. Minty, principal examiner, Patent Office; Mr. J. R. Sivess, deputy civil engineer, Admiralty; Mr. F. J. Taylor, M.I. Mech. E.; and Mr. R. McK. Wood, of the Royal Aircraft Establishment, are among those who have been created officers of the Order of the British Empire.

A Shipbuilding Trade Wages Advance.

IT was announced on Tuesday, June 5th, that following a conference of the executive committees of the various unions forming the Federation of Engineering and Shipbuilding Trades, it had been agreed by a majority to accept the offer made by the Shipbuilding Employers' Federation on February 16th at Carlisle to give a wage advance of 3s. a week, with certain exceptions, to plain time workers. It is understood that the craft unions, embracing the joiners, boilermakers, shipwrights, electricians, plumbers, and painters, are not affected by the settlement, as they recently approached the employers and suggested that either an improved offer should be made or the matter should go to arbitration. These demands were not acceded to, and the final decision regarding the advance to the plain time workers in these unions has still to be made. The first half of the new advance will become payable in July and the second half in September, but such payment is only to be made if the unions agree to discuss jointly with the employers the question of finding some index of prosperity for the industry by which wages fluctuations in the future may possibly be regulated. The unions will, we understand, appoint a committee to meet the employers and to discuss this question.

Aerial Surveying.

IN a Journal note in our isue of March 30th we intimated that the Aircraft Operating Company of London had secured a contract for the survey of Rio de Janeiro and the Federal District, covering a total area of 450 square miles, the survey to be carried out by a combination of ground methods and aerial photography. We now learn that the expedition, consisting of sixteen Europeans under the leadership of Colonel T. T. Behrens, is on its way to Rio de Janeiro. Two machines are to be used, one a Vickers "Vendace" seaplane with a "Nimbus" engine, and the other a de Havilland "Moth" seaplane fitted with Handley Page slotted wings. The chief pilot will be Captain F. H. Holland. It is expected that the actual photographic part of the work will be completed in about eight months. The same company also has in hand an air survey contract received from the Irak Government. An expedition to undertake this contract is now in Baghdad, and will shortly begin work under the leadership of Major Cochran-Patrick. A South African expedition under Major R. A. Logan is also about to start work. For this expedition the company is arranging to establish a permanent base at Bulawayo and to erect steel hangars there, if arrangements can be made with the Government of Southern Rhodesia.

New Motor Lifeboats for the Orkneys.

ON Wednesday of this week, June 6th, during his visit to the Orkney Islands, Prince George named the two new motor lifeboats which the Royal National Lifeboat Institution has built for its two most northerly stations at Stromness and Longhope. The Stromness station was founded in 1867, and seven years later the Longhope station was established. The original Stromness boat was of the pulling and sailing type, but in 1908 one of the first of three lifeboats to be converted to motor power was dispatched to Stromness. Last year we inspected the boat, the "John A. Hay," which is in remarkably good condition. She has a length of 42ft. and is 11ft. 6in. wide. The propelling machinery comprises a single 30 B.H.P. Tylor engine. This boat has been launched on service thirty-one times, and has been instrumental in saving ninety lives. The new boat is one of the Barnett cabin type, with a radius of action of 150 miles, and a speed of 8½ knots. She has a length of 51ft., with a beam of 13ft. 6in., and weighs only 26½ tons, which enables her to be hauled up into the covered boathouse by a power winch. Her propelling machinery comprises two units of the special completely submersible RNLI type, described in THE ENGINEER of February 17th, 1928, each of which is designed to develop 60 B.H.P. at 1200 r.p.m., the geared propeller speed being 600 r.p.m. At Longhope station the new boat is of the Watson cabin type, with a length of 45ft. 6in., and a width of 12ft. 6in. She is propelled by a single-screw RNLI engine, with six cylinders, having a designed output of 80 B.H.P. at 800 r.p.m., with a direct driven propeller. The new boat has a designed speed of 8 knots and her radius of action is 62 miles. Both the boats mentioned were built at Cowes, and made their journey to the Orkneys by sea.

A Proposed High-speed Railway.

MANY of our readers will no doubt recall having heard of the Kearney high-speed railway in past years, and not a few may have examined the model of it which was shown last autumn at the Shipping, Engineering and Machinery Exhibition at Olympia. It is interesting to note that steps are now being taken to give effect to a practical full scale trial of the system. On Tuesday of this week a Select Committee of the House of Commons, presided over by Sir Henry Jackson, began the consideration of a Bill promoted by the Kearney High Speed Tube Railway Company for the construction of a Kearney high-speed railway under the river Tyne, between North and South Shields. The system employed is on the switchback principle, with additional power supplied electrically. The journey through the proposed tube would be five furlongs in length, and would occupy about one minute. The cost of construction is estimated at £250,000, and the conveyance of 10,000,000 passengers per year is regarded as sufficient to provide a satisfactory return. It was stated by counsel for the company that the scheme had the support of the Ministry of Transport and of most of the local authorities. The Tynemouth Corporation is opposing the Bill on the ground that the real requirement of the situation is a road tunnel suitable for all forms of traffic. The Tyne Improvement Commissioners are also opposing the scheme.

Liverpool's New Power Station.

IN our Lancashire letter of May 25th brief mention was made of the new super-power station which the Liverpool Corporation, after consultation with the Electricity Commissioners, has decided to build on the river front. The new station will be one of the capital stations in the new electricity scheme for the supply of Lancashire, together with parts of Cheshire and Yorkshire. The site decided upon is the Clarence Dock, which the Corporation will purchase from the Mersey Docks and Harbour Board, at a price, it is stated, of £400,000. It is further understood that the Dock Board has also offered the Corporation the Trafalgar Dock site on equal terms, which enable the payments to be spread over ten years. The first part of the installation will comprise two 50,000 kW turbo-alternators with the necessary boiler and condensing plant. Part of the work which the Corporation will have to carry out will consist of the construction of a screening chamber, at the river entrance of the Clarence Half Tide Dock, together with intake and discharge culverts. A wall will also be built across the entrance to the Clarence Dock. It is proposed that the Corporation should provide for three-quarters of the cost of a new river wall. These proposals are now under consideration.

General Development of the Locomotive.

(By a Continental Engineer).

No. VIII.*

AMERICAN LOCOMOTIVES.

UNTIL the relatively recent and striking development of the railways in the United States the standard passenger engine was derived from the classic prototype well known as the eight-wheel or "American" type (4–4–0). The famous "999" of the N.Y.C. (1893), the Pennsylvania Railroad express locomotives and some others were the last examples of the type. Up to this period the development of the locomotive in the United States was even more uniform than it was in Great Britain, and very different from what was taking place on the Continent of Europe.

The classic eight-wheel engine was, from the first, very practically designed and adequate to the conditions then prevailing in the country; its structure was so appropriate to those conditions that many details of its construction have been retained to the present day.

It had a deep fire-box carried between the coupled axles, a leading bogie arranged as in modern engines, outside cylinders, and long connecting-rods. The valve chests were outside on top of the cylinders and the valves were driven by inside links and rocking shafts, an arrangement which remained an absolute standard up to the adoption of the Walschaerts gear.

The engines were very steady, flexible, strong, even rustic, and fitted for tracks of a light description and often uneven. The leading bogie was thus adopted on American railways as a standard, a long while before it was used, even exceptionally, on European and more especially on continental locomotives.

At the same period goods trains were handled by "Mogul" engines, and a little later by 4–6–0 locomotives having wheels of relatively small diameter. The "Consolidation" type appeared early; but, of course, in much less heavy and powerful models than the modern engine of the same type. Later, engines the 4–8–0 and even the 2–10–0 types made their appearance. From that period starts a new era in the development of the locomotive, which begins to attain dimensions and weights then unknown in Europe, a development that led up to the enormous engines of the present day.

American engineers attached from the first, and with reason, great importance to avoiding any overhang of fire-boxes or cylinders—except for shunting engines—and they have always kept strictly to that practice in the most modern locomotives having bogies or bissells, leading or trailing.

The European railway engineer is always surprised by the flexibility of American engines when passing with ease through curves of small radius in yards or depôts, which the stiffer engines of this side of the Atlantic could not negotiate even with a smaller total wheel base; it is the result of several arrangements and of the use of blind tires on one or two-coupled axles.

By reason of the extremely rapid development of the country and of the traffic, of the great number of single-track lines, and of conditions imposed by the necessities of service on the very long and severe inclines to be met with in some parts of North America, the increasing weight of the trains,† especially goods trains, reaching figures unknown in Europe, and partly the result of single tracks, and thanks to very strong couplings, the evolution of the locomotive towards new types more and more powerful as the time went, has been extremely remarkable. But these conditions would not have existed had not the country, in spite of some wastefulness in the beginning, been endowed with all kinds of natural wealth—coal, petroleum, wood, iron, not to speak of virgin and fertile lands spreading over immense territories. On the other hand, the enterprising spirit of the country, the energy and boldness, the inventive power of the engineers, have enabled full use to be made of these natural riches and has ensured, in less than a century, the wonderful prosperity of such a new country.

American makers and engineers have created with much skill, independence of mind and mechanical ability, under the pressure of necessity, most of the new types of locomotives in use now everywhere, at least in what concerns the arrangement of the wheels, coupled or not, the development of the boiler, very high pitched, and the application of the wide fire-box. Europe has followed them in this direction without going as far as they do, because it is not wanted, and by reason of a smaller structure gauge; on the other hand, American engineers have adopted some features of continental practice, such as the Belpaire fire-box—now given up for new engines—the Walschaerts valve gear, extensive applications of the Mallet articulated locomotive, and superheated steam. They are also beginning, on some very powerful engines, to use three cylinders, and even four cylinders for express engines. But, notwithstanding these facts, the locomotives used in the United States keep their national characteristics.

* No. VII. appeared June 1st.

† The almost general equipment of goods cars with the air brake, especially on lines having steep gradients, is, in a great measure, responsible for the length and weight of goods trains.

While in Europe, after the early days of the railways, the companies either built their engines themselves in their own shops, like most British and some continental railways, or ordered from makers locomotives of their standard types and from their designs, the American companies, with the exception of some large systems, such as the Pennsylvania Railroad, or the N.Y.C.R., until a relatively recent date, used to buy engines of models designed by the important makers, as was the case in Europe before 1845. This is so true that, in the United States, one may sooner recognise an American Locomotive Company's or a Baldwin engine than the locomotives of such and such company, with exceptions of course. This custom, so different from the European practice of to-day, had advantages regarding the cost and the rapidity of delivery, the makers having often in stock all the patterns and even many parts of the engines, more or less finished—such as wheels, cylinders, valves, and even fire-box dished plates, all the templates and gauges, &c. Thanks to this system and to a methodical organisation of the work, American firms have been able to deliver engines in record time. In some cases their work, once the order had been received, consisted almost solely—all castings and principal parts being stored beforehand—in the erecting and general fitting and adjusting.

This essentially American custom is now far from being as general as it used to be, but, even in the case of some important railways, it is not entirely done away with, and there exists, at least, a mutual understanding and collaboration with the makers.

This policy of the store and stock, though meaning an important advance of capital, is very business-like, and has contributed to the success and prosperity of American mechanical industry, in general, especially for exportation.

Modern American engines are too well known to call for any particular observations, except in one or two occasional cases, as we shall see later on. They are remarkable from many points of view, and particularly for their size and power. They are built on quite another scale than that used here. Their makers, helped by the large loading gauge, have shown how arbitrary were the limitations which were formerly assigned to the locomotive, and which have for a long while, by strange prejudices, hampered its development. The American engineer was the first to adopt very high-pitched boilers, notwithstanding their weight—up to 10ft. 6in. from the centre line of the barrel to the rail—very large boilers, and fire-boxes and total weights reaching in some cases 680,000 lb., with permissible axle loads exceeding often 33 tons.

The American tracks are strong, thanks to heavy rails and to sleepers brought closer together than in any other country, forming almost a continuous wooden bed.‡ If we except specially main lines east of the Alleghanies, they are not as well ballasted nor kept so even as in some European countries, and particularly in Great Britain, where permanent way is brought next to perfection. The rails, of the flange type, are fastened to the ties by mere spikes, not even screwed, and some of them are often loose. Security and good running—leaving nothing to be desired—are secured by the great number of sleepers, the good arrangement of the locomotive spring gears, and the absolutely general use of bogies, even for goods cars, and despite the enormous weights that the tracks have to support. Nevertheless, American trains do not give, when running, that impression of sliding on a perfectly even surface so characteristic of British railways, but we have to consider that America owns several hundred thousand miles of railways to look after. Moreover, the sleepers are too near each other to allow good packing of the sleepers. But, whatever be the quality of the road, the running is smooth enough, thanks to the great weight of the rolling stock fitted with six wheels bogies, and, in what concerns the engines, to the number of wheels, the total absence of overhang, and to equalising beams.

All types of locomotives are represented in the United States—most of them in reality created there—from the 4–4–2 and 4–6–2 type to the 2–10–2 and to different models of "Mallet" engines. Four-coupled engines are not to be met with nowadays on main lines, and, as in continental Europe, are no longer built, as a rule. The standard passenger locomotive is of the "Pacific" type, having wheels of different diameters, according to the profile of the lines or to the speeds of express trains. They vary from 70in. to 79in., and on important main lines they are at least of as great a diameter as on Europen engines, contrary to the old American practice. The modern "Pacific" engine—sometimes having an adhesive weight of 100 short tons—seems to be the last and most complete expression of the type, on the verge of becoming classical. It is well designed, powerful without exaggeration, symmetrical and as compact as the model allows. It is, in my opinion, the most happily designed locomotive of America. The standardised designs include two types, called "heavy" and "light" "Pacifics," but the light type weighs 277,000 lb. For the sake of comparison, we give below the principal particulars of the American heavy "Pacific" and one of the most powerful European engines of the same type:—

	American "Pacific" (Standard). 1919.	European "Pacific" (four-cyl. compound). 1912.
Total weight of engine in working order	306,000 lb.	209,000 lb.
Weight on drivers	197,000 lb.	122,000 lb.
Cylinders, diameter	27in.	17½in.
	—	25½in.
Stroke of pistons	28in.	25½in.
Diameter of driving wheels	79in.	79in.
Boiler pressure	200 lb.	225 lb.
Total wheel base	36ft. 2in.	37ft.
Boiler diameter	76¼in.	66in.
Tubes, length	19ft.	18½ft.
Tubes and flues, number	256	171
Total heating surface, superheater included	4,711 sq. ft.	2,800 sq. ft.
Grate area	70·8 sq. ft.	46 sq. ft.

Quite recently some American locomotive engineers have had to consider a further increase of the power of the "Pacific" type engine, at least in what concerns the boiler, the adhesive weight being sufficient with three-coupled axles loaded to the weight limit admitted in the States. The New York Central Railroad has ordered from the American Locomotive Company, and put in service, express engines of the "Baltic" class—called "Hudson" type in the United States—the three pair of coupled wheels being included between two bogies, the trailing one under the fire-box. This disposition has enabled both the grate area and the heating surface to be increased. These engines, having driving wheels of 79in., are designed for the *de luxe* express trains of the above-named company.

Similar arrangements, made in order to use larger grates and heavier boilers, as regards the substitution of a trailing four-wheeled truck under the fire-box, to the usual trailing axle, for Pacific, Mountain and Decapods, has been recently adopted by several railways (Great Northern, Burlington, &c.) This practice seems destined to spread in the United States. We have seen that it also has been adopted by the P.L.M. road for its latest tank engines of the 4–8–4 type.

The "Mountain" type, of recent creation, has been adopted to run exceptionally heavy train units in both passenger and fast freight service, on lines having steep gradients, more particularly by the Union and the Southern Pacific, or the Santa Fé Railroads. It constitutes the development of the "Pacific" type, and is mounted on wheels of smaller diameter.

A good example of the "Mountain" type is to be found on the Topeka Santa Fé Railroad. Total weight, 396,000 lb.; weight on drivers, 309,300 lb. (or about 35 tons (short) per axle); grate area, 75 square feet; heating surface, 6626 square feet; diameter of driving wheels, 63in.; total wheel base, 41ft. 7in.

A 2–10–2 type engine, in general use on lines having heavy gradients has, as an average, total weight, 370,000 lb.; on drivers, 245,000 lb.; grate area, 75 square feet; heating surface, 5900 square feet; diameter of drivers, 69in.; total wheel base, 39ft. 6in.

The 4–8–2 type reaches a total weight of 352,000 lb., with a tractive power of 58,200 lb.

It may be said that these two last types have been brought up to the possible limits, and the adoption of the "Mallet" compound opened possibilities which made it successful on the American systems having a heavy traffic on lines with steep and long climbs. The "Mallet" arrangement—which has never met with favour in its country of origin save for the metre gauge—has experienced an extraordinary development and given rise to some enormous engines exceeding all that could have been foreseen. They belong to several types: double "Mogul" with a weight of 448,000 lb. and a tractive effort of 80,000 lb.; double "Consolidation," 530,000 lb. and 100,000 lb.; double Decapods (2–10–10–2), 635,000 lb. and a tractive power of 147,000 lb. Two of these last engines and one "Mallet" of the 2–8–8–2 type can haul a train of 5200 tons up a gradient of 2 per cent. and 10 to 12 miles long.

There have also been built some triplex "Mallet" locomotives having six cylinders and eighteen driving wheels, six of them under the tender.

Some American makers have, within recent years, applied boosters to locomotives of the 4–6–2 and 2–8–2 types, principally driving the trailing axle to facilitate the starting, and arranged to be disconnected when the speed has attained a certain figure. This apparatus is ingenious and well designed, but the problem to be solved offers serious difficulties, and it is not yet possible, I think, to ascertain whether the use of this apparatus is likely to become general practice or must be considered as of rather exceptional application.

In America, tenders, as said above, are not considered as a part, an extension, so to say, of the engine, as in Europe and especially on British railways, but as cars of a special class being solely designed to carry the necessary fuel and water. As the engines are powerful and the distances to be covered often very long, some of these tenders have a capacity unknown in Europe, as much sometimes as 15,000 gallons (U.S.) and 20 tons of coal, constituting a serious deadweight. They are always supported on two trucks, with six wheels for the large tenders.

The standard tenders are box-like, and the tanks

‡ Owing to the increasing price of timber there is a marked tendency in the United States to pitch the sleepers more widely than hitherto.—ED. THE E.

are of the horseshoe type—as in continental Europe—but those of the very large engines—"Mountain," "Decapod," "Mallet," &c.—are often more or less cylindrical in shape.

Quite recently some makers have introduced tenders having all their plates welded, with a total absence of rivets, giving a very smooth surface.

This brief account is sufficient to illustrate in what measure the working conditions are different in America, and to render conspicuous the initiative of her engineers. Many are inclined to think that they have gone too far, but we must not judge their achievements with European eyes, and they have facilities which we shall always lack, and which have helped them to make of the locomotive a machine outdoing the conceptions of the old world, where the traffic is conducted under very different conditions. However, we have to acknowledge the considerable influence of American practice on the recent evolution of the locomotive in Europe. It has been our teacher in many respects, but, locomotive engineers on this side of the Atlantic, far from copying it integrally, have consulted it, have profited by it, and adapted the American experience to their operation methods. Nevertheless, American makers have been precursors in the sense that we owe, in a great part, to their influence, new powerful types of engines such as the "Prairie," "Mikado," and "Pacific."

(To be continued).

New Waterworks for Broadstairs.

WE were recently invited to inspect the Rumfield's pumping station of the Broadstairs and St. Peter's Urban District Council, which has been remodelled, the old plant, which was steam operated, having been dismantled, and its place taken by an up-to-date pumping installation driven by heavy oil engines. In addition several extensions and improvements have been carried out.

The station lies at a distance of some 1¼ miles westward of, and inland from, the town. The works were originally established in 1859, and were purchased by the local authority in 1901. The supply is derived partly from wells sunk into the chalk, and partly from the Fleete reservoir of the Margate Corporation, under an agreement entered into between the two authorities and confirmed by the Broadstairs and St. Peters Urban District Council Act, 1923.

The original pumping plant consisted of the following:—(1) One deep well pump in the main well, which had a nominal capacity of 25,000 gallons per hour. This pump was driven by a Summers and Scott tandem-compound condensing steam engine. (2) A Worthington duplex triple-expansion force pump, erected in 1900, which had a capacity of 40,000 gallons per hour, and a similar Worthington pump, date 1908, but with a capacity of 60,000 gallons per hour; and (3) a small Worthington booster pump, which was used to pump Margate water to the softening plant—to be referred to later—when the pressure was otherwise insufficient. The steam generating plant comprised: (*a*) A very old Cornish boiler; (*b*) a Davey Paxman Lancashire boiler; and (*c*) a Ruston and Proctor semi-portable locomotive type boiler. The whole of the foregoing plant was superseded, and there have been further changes and some increases in capacity in various parts of the plant which will be mentioned in due course. The original plant, owing partly to difficulty in effecting repairs, since it was not completely duplicated, had fallen into a state of inefficiency. The new plant was designed not only to give duplification throughout, but also to reduce the working hours and wages cost per 1000 gallons.

The scheme for the reorganisation of the works was prepared by Messrs. H. Rofe and Son, consulting engineers, of Westminster. The main contractors for the supply of the new machinery were Ruston and Hornsby, Ltd., of Lincoln, the pumps and the electrical machinery and accessories being provided by Mather and Platt, Ltd., of Manchester, as sub-contractors.

As in the majority of cases of a similar nature, it was necessary, when substituting the new machinery for the old, first of all to maintain the continuity of supply, and, secondly, to make the new plant fit into the then existing buildings with a minimum of alteration. Both conditions were fulfilled in the present instance, and by an ingenious arrangement of the new machines, all the structural alteration necessary was the enlargement of an aperture in one internal wall. The lay-out of the pumping station, prior to the remodelling, is shown at the left-hand side in the plan given in Fig. 1. The various buildings have been retained and re-employed, and the structural alteration of which mention has just been made was the removal of the wall separating engine-house No. 1 from engine-house No. 2.

The arrangement of the reconditioned engine-house as it now exists is shown in Fig. 2, while internal views of it are given on page 630. The new machinery comprises, first of all, two three-cylinder 150 B.H.P. vertical four-stroke airless-injection oil engines made by Ruston and Hornsby, Ltd. These engines have cylinders 12in. in diameter by 17in. stroke, and they are designed to run at a speed of 300 r.p.m. They are of the makers' standard cold-starting type, which are intended to develop full load on heavy oil fuel, including oil of up to 0·95 specific gravity, and do not call for any detailed description, as their construction is well known to our readers. Each engine drives two separate pumps—(*a*) a well pump and (*b*) a surface pump—designed to operate against a total head of 115ft. The well pumps are Mather and Platt "Plurovane" vertical-spindle, four-cell, high-lift turbine machines, with 7in. suction and 6in. delivery branches, and each is designed to deliver 600 gallons of water per minute against a total head of 190ft. at a speed of 1000 revolutions per minute. That speed is obtained by means of gearing, a cast steel bevel wheel, driven from the crank shaft, meshing with a forged steel pinion, the ratio being as 1 to 3·3. Both bevel wheel and pinion are mounted on short forged steel shafts, which run in phosphor bronze bearings. The gear was made by David Brown and Co., Ltd., of Huddersfield. The engines are arranged with their crank shafts parallel with one another, and at a distance apart of some 3ft. centre to centre, the fly-wheels of the two engines facing one another, with the well in between them. The crank shaft of each engine is prolonged beyond the fly-wheel, and on each shaft is keyed one member of a friction clutch, the other member being keyed to the same shaft as the bevel wheel which operates the well pump. The friction clutches are actuated by screws and hand wheel gears. The vertical shafting, which in the two cases drives the impeller of the well pump, is 2¾in. in diameter and 165ft. long, and it is taken down to the pump inside the delivery pipe, being carried in *lignum vitæ* bearings, which are secured between the flanges of the pipes. It is connected to the short shaft which carries the pinion of the driving gear by means of a pin coupling, and a Michell thrust bearing is interposed between the coupling and the shafting to take the weight of the latter and of the pump impeller. The arrangement of the gearing and of the bearing is well shown in Figs. 3 and 4, and no further description appears to be necessary. It will be understood that the whole of the weight of the pump with its shafting, together with that of the delivery main, is supported from the top of the well, there being no staging at the bottom or anywhere up the sides of the well. Exactly the same arrangement is followed for both pumps. A considerable amount of skill was required to fit the new machinery and pipes into the somewhat cramped space available, and the work has been exceedingly well designed and carried out. It may here be explained that the diameter of the well is only 6ft., and the overall diameter of each pump casing was slightly over 2ft. 6in.

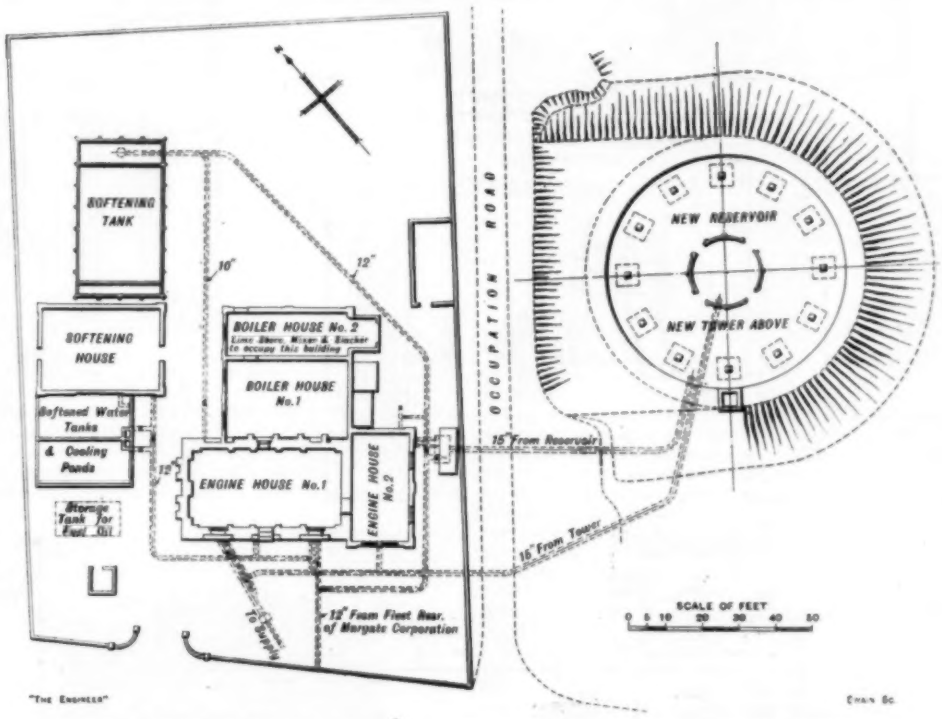


FIG. 1—PLAN OF ORIGINAL RUMFIELDS PUMPING STATION, AND NEW RESERVOIR

The discharge from the well pumps is into a sump tank, under the engine-house floor. The well water is of great purity, but it has some 20 deg. of hardness. Consequently, before being supplied to consumers, it is softened by the addition of lime. The lime water is thoroughly mingled with the incoming well water by allowing the former to pass up through a vertical pipe arranged centrally in a pipe of larger diameter, which has a bell-shaped mouth, over the lip of which the well water coming up the annulus between the two pipes, flows into a reinforced concrete softening tank outside the engine-room. The mixing of the liquids is quite satisfactory, no additional stirring being required. The dose of lime given is sufficient to reduce the hardness figure to about 8 deg. The Margate water is not quite so hard as the Rumfields well water, being only of some 18 deg., but it, too, is softened by the addition of lime, being mixed with the Rumfields water in the softening tank.

The capacity of the softening plant in the original station was 30,000 gallons per hour. That has been doubled in the remodelled plant so as to correspond with the capacity of the force pumps. As the installation of oil engines left the two boiler-houses vacant, the smaller of the two has been utilised for the lime store and the lime-mixing plant. That arrangement has allowed of additional filters and lime solution cylinders being placed in the original softening plant house, so that no new buildings were necessary. A new and additional underground tank for the storage of softened water has, however, been constructed, and its roof has been employed to form a cooling pond for the water circulating in the jackets of the engines, as will be explained later.

The lime solution is pumped into a battery of solution proportioners, made by Charles J. Haines and Co., Ltd., of Worple-road, Wimbledon, which are contained in the softening house—see Fig. 1. Through these proportioners a certain percentage of the water pumped from the wells is allowed to flow, and is there mingled with the quantity of lime water required for the treatment of the whole body of water. The discharge is through the open top of a vertical pipe arranged centrally in each proportioner, the level of the top of the pipe being at such a height that the liquid can flow by gravity into the softening tank, through the vertical inlet pipe in the latter as already explained.

It is necessary, of course, to remove the precipitated matters from the treated water, and that is effected in a series of six filters of the Haines type, which are in the same building as the lime-proportioning tanks. In these filters the precipitate is arrested by filter cloth bags, arranged vertically in rows side by side. When the cloths become clogged so that the flow of water through them falls below a predetermined rate, the filter is cut out of circuit, and the arrested matters are washed off the bags by means of water sprays, which are directed upon them, and which can be moved up and down by toothed gearing and a hand wheel, so that all parts of the bags may be operated upon. The matter thus removed is, at present, being used to fill up excavations near the pumping station.

The filtered water, which is beautifully clear and bright, flows by gravity into the underground storage tank, already mentioned, part of which comes under the filter-house floor, and from thence to the suction sump for the force pumps. The latter are, as has been said, operated by the same engines as are the well pumps, but, owing to the necessity of arranging the machinery in a given space, the method of driving is not the same for each. Both pumps are of the same size and type, both being Mather and Platt "Medivane" single-cell horizontal spindle machines, with 8in. suctions and 6in. deliveries, each being designed to handle 1000 gallons of water per minute against a total head of 115ft. when running at 1300 r.p.m. It will be remembered that the engine speed is 300 r.p.m., and the increase in speed necessary for driving the pumps is obtained, in the case of one pump, by means of machine-cut double-helical gearing, made by David Brown and Co., Ltd., which is

connected to the crank shaft, at the end remote from the fly-wheel, by means of a flexible coupling, the crank shaft, of course, being prolonged beyond its bearing for the purpose. The other pump is driven by belt from a pulley operated from a prolongation of the crank shaft, a weighted lever belt tightening gear of the Flenco type, made by F. L. Smidth, of Copenhagen and London, being provided. In this case there is a hand-operated clutch between the crank shaft and the pulley shaft. The belt with this type of drive is cemented and not sewn, on account of both faces of it having to bear on pulleys, and the considerable lap round the pump shaft pulley, which is effected by the weighted lever, has enabled the centres of the driving and driven shafts to be only

concrete water tower. The original water tower of the old station, which was constructed in 1876, consisted of a cast iron tank of 70,000 gallons capacity. It is over the engine-house and its top water level was 206ft. above Ordnance Datum, or some 51ft. above ground level. Neither the capacity nor the elevation of this tank being sufficient, the new tower, which has a capacity of 250,000 gallons, and a top water level of 250ft. above O.D., was erected. It has an internal diameter of 60ft., the depth of water being 14ft. 6in., and it is built over the top of a covered circular underground reservoir, which has a capacity of 300,000 gallons. The foundations, which are on chalk, consist of isolated footings, which support the superstructure of the tower, and also the floor of the

Fig. 5—is, be it said, one of the least unsightly that we have seen. Indeed, it is almost graceful in its design and its constituent parts are very well proportioned. The central shaft or tower is a noteworthy feature in its construction. It not only serves as a means of access and for housing the pipes, but it also takes a considerable proportion of the wind pressure. That fact has allowed of the sizes of the columns, which normally have, by themselves, to bear the whole of that pressure, to be reduced, and that has naturally added to the appearance of the tower. The structure was built to the design and specification of the consulting engineers, the Indented Bar and Concrete Engineering Company, Ltd., being responsible for the reinforced concrete details, and the contractors,

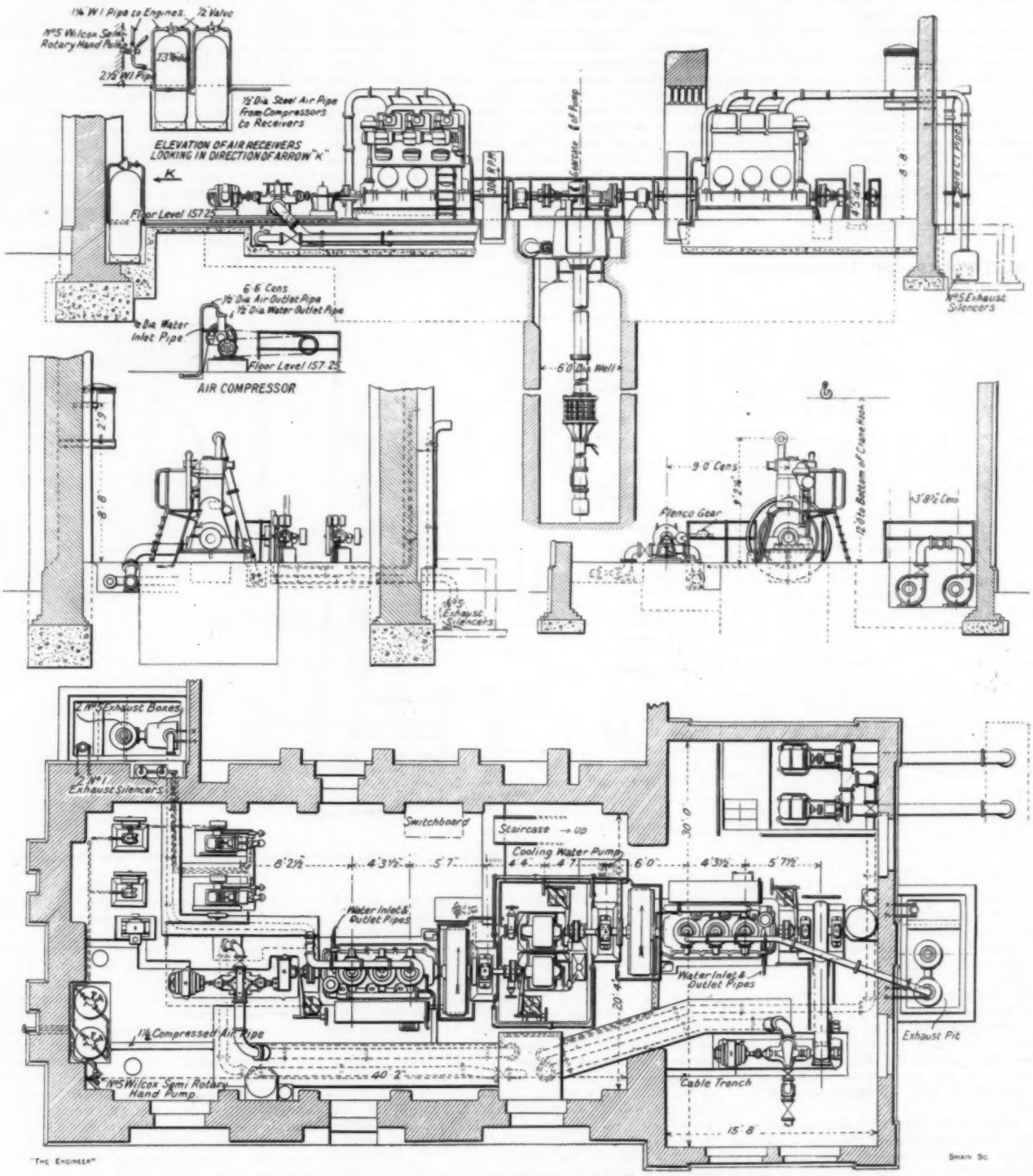


FIG. 2—ARRANGEMENT OF RECONDITIONED RUMFIELDS ENGINE HOUSE

8ft. 6in. apart, which has naturally resulted in a saving of space.

The spindles of both the surface pumps are extended, and each is coupled to an open end bracket compound-wound dynamo, also made by Mather and Platt, each machine having an output of 12·5 kilowatts, at 240 volts, when running at a speed of 1300 r.p.m. These generators provide current for lighting and for driving some further pumps which will be referred to later. The surface pumps, and their generators, are in each case mounted on a cast iron combination bed-plate, the whole forming a neat and compact arrangement.

The surface pumps deliver direct into the mains running into the town, and any surplus pumped beyond the current requirements of the distribution network, is delivered into a new circular reinforced reservoir below. This reservoir has an overall diameter of 66ft., and an internal depth of 15ft. 9in. from the underside of the roof, the depth of water being about 15ft. The roof is supported by the columns which carry the superstructure of the tower, and by radial beams spanning between the outer columns and the pilasters on a central shaft, which latter is tied together by a series of ring beams.

The floor of the tank at the top of the tower is also supported on a series of ring beams connected with the columns and practically following the same lines as the column braces, the radial beams being cantilevered out to support the overhanging portion of the tank floor. The haunches of the outer beams are curved, as are also the cantilevered portions of the radial beams.

This water tower—a view of which is given in

Messrs. Rice and Son, of London and Margate.

It may here be explained that, ordinarily, it is only found desirable to pump from the well at the rate of 600 gallons per minute for a period of some eight hours each day, water required above that quantity being obtained from Margate. One well pump is therefore of ample capacity to perform the whole of the work required, and it is customary to run the two sets day and day about. When pumping at that rate the level of the water in the well is sensibly lowered, and it is not practicable to work at that capacity much longer than eight hours at a stretch. During the sixteen hours' rest, however, the water rises again to its natural standing level. Pumping is arranged to coincide with the time of maximum demand in the district—roughly between 8 a.m. and 4 p.m.—and the demand during the remainder of the twenty-four

hours is, ordinarily, met from the water tower. The total amount of water pumped, less the small proportion which is used for forming the lime solution, is registered by means of a Venturi tube and a Kent recorder.

The water from Margate is normally received at this pond, entering it at one side. At the other side there is a sump from which two small centrifugal pumps—one driven by belt from the crank shaft of each engine—draw the water for circulation. The temperature of the cooling water, as it leaves the engines, is about 115 deg. Fah., and the duration of the for any reason, there is a ball cock by means of which the water in the tank may be kept at the proper level by water from the mains.

The exhausts from each engine are taken separately into pits outside the building and the silencing is very efficient.

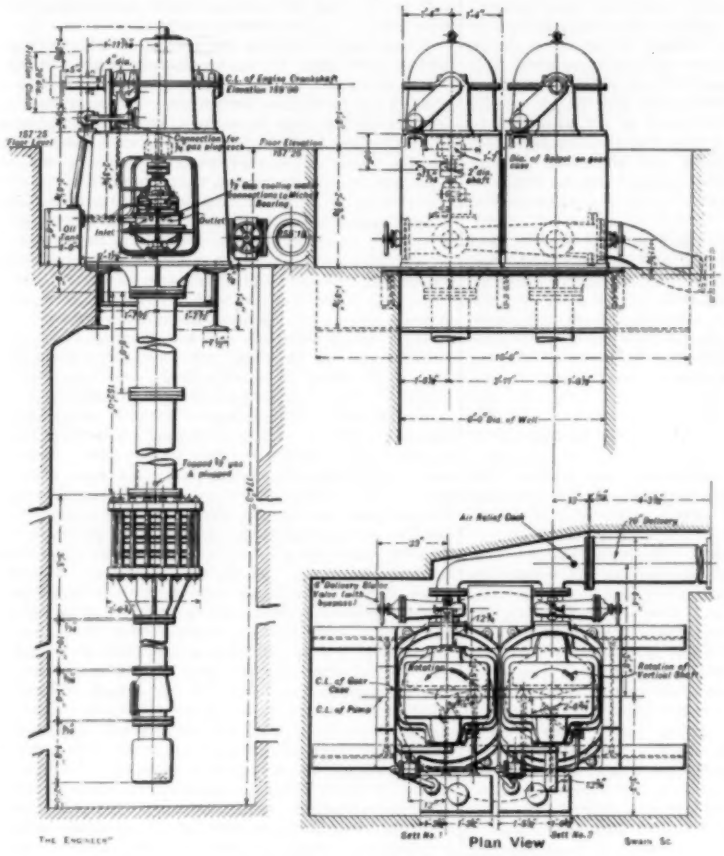


FIG. 3—ARRANGEMENT OF WELL PUMP AND GEARING

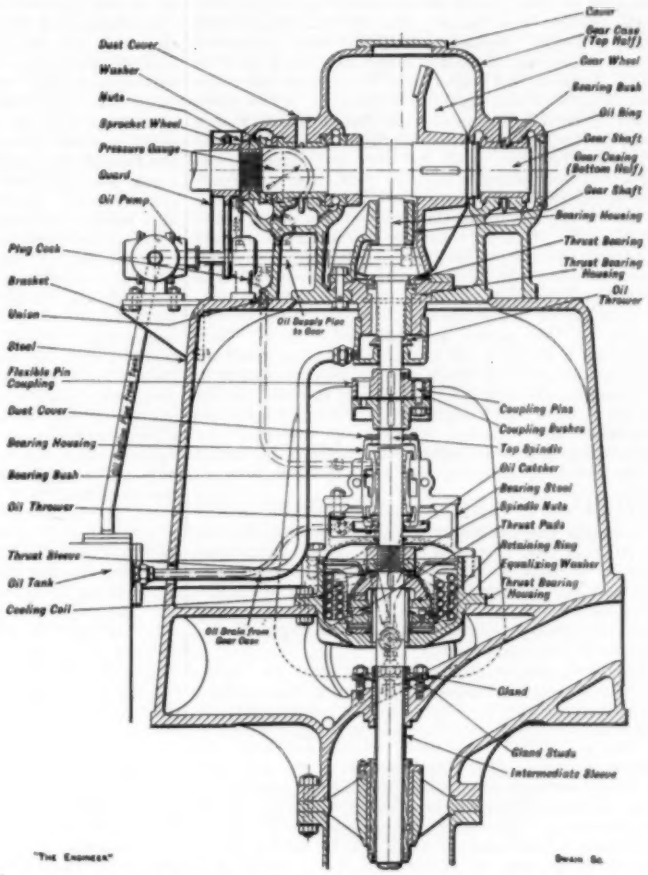


FIG. 4—BEARING AND GEARING AT HEAD OF PUMP SPINDLE

sufficient pressure to reach the softening plant, but that cannot be relied upon in periods of maximum demand. Two auxiliary sets, each consisting of a Mather and Platt "Solovane" type pump, electrically driven by a variable-speed electric motor, are therefore provided, having a maximum capacity of 1000 gallons per minute, which can pump from the underground reservoir, already described, to the softening plant, or alternatively direct to the suction sump of the force pumps.

The starting of the engines is effected by means of compressed air. The necessary equipment comprises two Ruston 5 B.H.P. paraffin oil engines, arranged for quick starting with petrol, each of which is coupled direct to a Ruston two-stage air compressor, the compressed air being delivered into either of two steel containers. The starting air pressure is 300 lb. per square inch, and the arrangements are such that either compressor can charge either container, and that air can be admitted to either engine from either container. In order to furnish current for lighting when neither of the larger engines is at work, one of these small compressor engines is arranged to drive a small 2½-kW, 240-volt dynamo by belt.

The remaining arrangements of the station, like the main pumping plant, are very complete and well thought out. The store of fuel oil is contained in two reinforced concrete tanks arranged below ground level outside the pump house in the position seen in Fig. 1. The combined capacity of these two tanks is 20 tons. The fuel is raised from either one or the other of these tanks by means of a hand-operated semi-rotary pump arranged in a corner of the engine-room, into either one or the other of two service tanks fixed on the walls of the engine-room at the required height to feed the engines. The lubricating oil is pumped from the drainage sumps in the engine beds, to which it gravitates after use, to a tank fixed to the wall of the engine-room, where steam, furnished by a small boiler in an adjoining room, is injected into it. The result is the precipitation of the majority of the foreign matter in the oil, the remainder, together with a large proportion of the water taken up from the injected steam, being removed by means of a small motor-driven centrifugal. The oil comes from the latter clear and bright, and we gathered that it is only necessary to add one part of fresh oil to four parts of the treated oil to render it fit to use again in the engines.

For the cooling water also, the arrangements are most complete. There is, first of all, the concrete pond just outside the engine-room, which is open to the air and which is capable of containing some 8000 gallons of water. The water coming from the jackets and cylinder heads of the engines flows by gravity into passage through the cooling pond is long enough to lower that temperature through the requisite number of degrees without the necessity of resorting to sprayers or similar devices. The little pumps on the engines raise the cooled water into a tank capable of holding

FIG. 5—250,000 GALLON WATER TOWER

600 gallons, which is fixed on the floor of a room at a height of some 22ft. above the engine-room floor and from which the engine jackets are fed by gravity. For use, should either of the small pumps break down, or in case of failure of the circulating water system

The station switchboard comprises two slate panels, arranged on an angle iron framework, which are equipped with the necessary apparatus for controlling the two main generators and the one emergency machine—of which mention was made above as being driven by one of the air compressor engines—with two feeder circuits to the motors, and with one circuit for lighting. For controlling the motors which drive the reservoir pumps there are two Brook-Hirst drum type ironclad control panels which are mounted on the floor of the engine-house and are furnished with glazed doors.

The whole installation forms an extremely interesting example of modern waterworks engineering, and the new plant has, we understand, operated with complete success since it was put into service.

A Century of Inventions.*

By Sir JAMES ALFRED EWING, K.C.B., M.A., LL.D., D.Sc., F.R.S., M. Inst. C.E.

THE Council, when inviting this address, suggested a very comprehensive text, namely, a prediction which Thomas Tredgold added to the definition of civil engineering which he drew up for the petition for a Royal Charter presented in 1828. It ran thus: "The scope and utility of civil engineering will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical science." Seldom, surely, has a prophecy been so justified in the event. Every advance in scientific theory has increased the engineer's mastery of the material world. Discoveries, which at first may have seemed wholly unserviceable to him, have, in fact, furnished new points of departure, leading in ways that were often unforeseen to enlargements of his many-sided art. It may be doubted whether even Tredgold, with all his vision, saw the other side of the picture; whether he realised the beneficent reaction by which science was itself to profit. But we, at any rate, see it now. We see how developments in science are fostered and even initiated by industrial requirements, by engineering enterprise; how inventions that were made for the purpose of serving a public need have widened the outlook of science and given it new tools for research. From modest beginnings physical science and engineering have advanced, side by side, and in the advance their intimacy has developed; they have discovered the advantages of

* The Institution of Civil Engineers. The Thirty-fourth James Forrest Lecture, June 4th, 1928. Abridged.

relationship and the relationship has itself become closer.

In this review we have to go back further than the reach of even the longest individual memory. Try to realise what engineering meant in 1828, what was its relation to the science of the day, and what in fact was, in that day, the state of science. The engineers of that period were mainly concerned with roads, bridges and canals; the era of railways was about to begin. Macadam had just been appointed Surveyor-General of Roads. He and our first President, Telford, had contributed to convert the roads from sloughs of despond into highways. A few years earlier Telford had spanned the Menai Straits with a chain bridge, to take the Holyhead road; and the Southwark Bridge, with its cast iron arches, was erected to the designs of Rennie. But these structures were exceptional; it was a rare thing then to build a bridge of iron. During the half-century or so which precedes the date we celebrate, canal projects were promoted with something of the enthusiasm which later attended the development of railways. The commercial success of some ventures was so conspicuous as to bring about a "canal mania." The success of the canals wrought their ruin. They developed a public need which became too great for them to satisfy, and drove men to seek a solution in the creation of railways. The canal interest, strong though it was, could not stay the coming of a more adaptable and quicker method of traction. In engineering, as in other affairs, the better is the enemy of the good. Naturally, the good did not love its enemy.

Though the Stockton and Darlington line, first of such public enterprises, was opened in 1825, it was not till 1829 that Stephenson's "Rocket," when tried against competitive engines on a section of the Liverpool and Manchester Railway, settled the much disputed question whether steam locomotives should be used, and determined also the general lines of subsequent locomotive design.

The steam engine, beginning as a device for pumping water out of mines, had been adapted by Watt and his followers to the driving of machinery in factories, and had thereby become a potent agent in the industrial revolution which followed the Napoleonic wars. It had been applied experimentally to drive carriages on roads and had established its position especially in America, as the motive power of paddle boats for river traffic. To a small extent steam was being adopted as an auxiliary in sailing ships, and reformers were urging that the Navy should give it a trial.

Watt's prejudice against the use of high-pressure steam for a long time dominated English practice. Nevertheless, Jacob Perkins, rightly described by a contemporary as "an experimenter of no common cast," ventured even before 1828 on pressures such as would still be considered very high. But Perkins was one of those unfortunate inventors who are born before their time. What is relevant for us to notice is that in those days the theory of steam was even more rudimentary than the practice; the early development of the steam engine proceeded without the guidance which it would have had if the properties of steam had been known. Carnot had already written his wonderful essay on the motive power of heat. But it had fallen flat. Its meaning was not appreciated; and at the time of which I speak, the very alphabet of thermodynamics had still to be framed.

Remember that those early steam engineers had no idea that what they were doing was to convert heat into mechanical work. Many years were to pass before the notion of energy, as a thing neither produced nor destroyed, was to become an established part of natural philosophy; before Joule determined the mechanical equivalent of heat, and the first principles of the subject were formulated by Kelvin and Rankine and Clausius. But it may fairly be claimed that the way was prepared for these conceptions by the work of the engineers, by the invention and frequent use of the indicator, by Watt's numerical definition of the term "horse-power," and by the sporting interest of the Cornish mine managers in the "duty" of their engines, a figure which expressed the relation of what we now call the work done to the coal consumed.

When one looks into the technical literature of that period one is sorry for the early student of engineering. Physicists and engineers alike were groping their way, confusedly, towards mechanical ideas which were as strange then as they are familiar now. The mathematical theory of elasticity is described by its historian Todhunter as having had its birth in 1821, when Navier first gave the equations for the equilibrium of elastic solids. Navier had brilliant colleagues among the other mathematicians of France. But between them and the stolid practicians of Westminster there was a wider difference than one of language or political sentiment. Their ways were not as our ways. Tredgold, in a preface to his "Essay on the Strength of Cast Iron," which discusses the strength of beams, goes so far as to repudiate the use of fluxions as unsound. He appears to have regarded a differential coefficient as a device for "forcing the assent rather than convincing the judgment." This prejudice against the calculus remained for long a serious handicap to the British student of engineering. Teachers misspent their ingenuity in dodging the calculus; they often led the student to think of it as mysterious and unattainable when he ought to have been learning not how to avoid, but how to use what is really an indispensable intellectual tool. The bogey is now pretty well laid, thanks in great part to the unconventional yet effective teaching of the late Professor John Perry.

Not less than mechanics and heat, the science of electricity was still in its infancy. It was not till the requirements of the telegraph had to be met that the engineers and physicists together attacked the problem of framing a logical system of electrical units, determined their magnitude, set up standards, and established practical means of comparing electrical quantities with them. The work was begun in the early 'sixties, under the auspices of a Committee of the British Association, of which the secretaries were Clark Maxwell, the physicist, and Fleeming Jenkin, the engineer. What it accomplished was an incalculable boon to the investigator in pure science no less than to the technician.

To be able to measure—that, as Lord Kelvin used to say, is in any subject the first step towards real scientific knowledge. Till you can measure quantities and express them in numbers you may have the beginnings of knowledge, but you cannot claim to have reached even the beginnings of science. Not in electricity only, but in mechanics, in heat, in all the properties and actions of matter where engineers and physicists find common ground, it is through the alliance between science and practice that the art of measurement has been evolved. Our knowledge of physical constants and of the properties of materials, our units and scales and instruments and testers of all sorts, are for the most part offspring of the marriage of science with practice. They make science exact, and they allow engineering to be standardised.

It was to meet the rapidly growing needs of steam engineering that Regnault undertook his researches into the properties of steam which led to the publication, in 1847, of tables and data which for long remained a classic of the engineer. Now, thanks to Callendar, Mollier, and other workers, we enjoy a fuller and more accurate knowledge of these properties than Regnault could achieve, hampered as he was by the uncertainties of early thermometry. The science of thermometry became definite only after Kelvin introduced the absolute scale of temperature—a brilliant philosophical conception which runs through all physical and chemical science like a thread of gold in a woven fabric. It guides the engineer to the ultimate standard of thermodynamic efficiency, and it was from meditating on the action of heat engines that the inspiration came.

It was to meet the requirements of the naval architect that William Froude attacked the problem of ship resistance, devised the method of the experimental tank, and showed how measurements on the drag of small models might, through application of what is now called the principle of dynamical similarity, furnish data from which to determine the power required at any speed to drive the largest ships.

It is to aid engineering no less than pure science that we now supplement private enterprise by the official organisation of research. In this it must be admitted that we followed somewhat slowly the example set by continental neighbours. The National Physical Laboratory was promoted by the joint efforts of physicists and engineers. It was, from the first, fortunate in having for its head a man in the fullest sympathy with both schools of thought, who, for many years and with the happiest results, applied his faculty for leadership to build up an establishment whose work is accepted as authoritative and whose influence on the scientific development of engineering has been, and continues to be, profound.

The war turned men's thoughts, as never before, to mechanical problems. From being questions of mere luxury or convenience, such problems became, almost suddenly, questions of national life or death. Physicists and mathematicians whose interests had been wholly abstract were brought, as it were, from the clouds to earth. They faced facts—often, one should add, to excellent purpose. With the community generally, applied science took on a new significance; till then it had meant little to them; they now saw it as a man struggling in the water sees a plank within his reach. Research, and the adaptations of research, from being treated with general indifference, were hailed as a way to public salvation—salvation not only from the immediate menace of the struggle itself, but (after that was past) salvation from the abiding danger of international competition and the burden to industry through waste and debt. The national intelligence was stirred; blind eyes were opened. They have remained open, and the Department of Scientific and Industrial Research does much to keep them open. You have only to glance at its annual reports to see the great range of its activities. It undertakes researches of a type no private worker could attempt. The Department also subsidises young research workers. For a young worker to attempt research is often a useful education, and he may discover a real aptitude. But we must not forget that researchers, of the best sort, are like poets; they are born, not made. But, when the right man is found, there is no limit to his potential achievement. He may give the world a new idea; he may create a new industry; he may make for himself a name; he may make, generally for others, a fortune. Of late the practice has sprung up in the great manufacturing corporations of engaging the services of a team of researchers, and placing the best laboratory equipment at their disposal. One is glad to know that this procedure has been found to pay. Some corporations take a wise line in giving the researchers a free hand—a roving general commission of inquiry—not limited to points of immediate utility. There are notable instances where this has led to discoveries and inventions which more than justify such a policy on its economic side.

From time to time in the history of engineering we find a new idea born, resembling what biologists call a sport, which gives an unexpected turn to the process of inventive evolution. No one can confidently extrapolate the curve of engineering progress. Its equation is liable to capricious change. And besides those occasional fresh departures, we find, especially in modern times, that the scientific method is continuously at work, acting always as an auxiliary to experience in improving what is already familiar. Thus the influence of science is felt in two ways; in occasional spectacular events which open up channels where the stream did not flow before, and also in constant guidance of established currents, giving them greater volume and a more favourable course.

Take an illustration or two from the history of metallurgy. In 1828 the only forms of iron available for construction on a large scale were pig iron, the product of the blast-furnace, and puddled iron, the same product decarbonised in the reverberatory furnace. When railways began there was doubt whether rails should be cast or wrought. Wrought iron had Stephenson's support and won the day. But it was not easy for the output of puddled metal to keep pace with the rapidly increasing demand which arose for rails, for boiler plates, and presently also for ship plates when iron came into use as the material for building hulls. It became urgent to find some other way of obtaining iron in the malleable state. In 1856 Bessemer attacked the problem as an outsider who broke away from the traditions of the trade. His method was a sport, but no accident; it was an outcome of scientific thought. His first success was quickly followed by failures which only stimulated him to investigate their cause and cure. The difficulties were overcome, and mild steel began slowly to take its place as the most valuable of all constructive materials known to the engineer.

A few years later the alternative process of the open hearth was developed by Siemens, not less novel, and not less an offspring of scientifically trained intelligence. Regenerative heating—an idea which had already found engineering expression in the Stirling air engine—secured the high temperature necessary for the molten bath. Less simple and less rapid than the process of Bessemer, it had the advantage of easier control; it could be made static. Each method has its own field of usefulness; together they supply the world with nearly a hundred million tons of steel a year.

By means of subsequent study, the engineer is provided with cutting steels which have revolutionised workshop practice; stainless steels, whose use goes far beyond the requirements of the cutler; mechanically strong and wear-resisting steels in a profuse variety; magnetically hard steels which are retentive of magnetism to a degree not approached before. It would seem you have only to specify a new requirement, and the metallurgist finds an alloy that will meet it.

It is a scientific process of high-temperature electrolysis that has made aluminium a commercial product. The designers of aircraft and of motor cars appreciate its value, in the alloyed state, and one may conjecture that in many fields of engineering construction we are on the threshold of an aluminium age. A material, not too costly, which has nearly the strength of mild steel, with little more than one-third its weight, ought to have an unlimited future. It has even been suggested that for the new age we should look to the alloys of another and still lighter metal, magnesium. Research in these directions proceeds apace.

A century ago the development of the steam engine had not emerged from the empirical stage. A change came soon after 1850, when men began to think of energy as protean and imperishable. The mechanical theory of heat was established, and in 1859 Rankine published his "Manual of the Steam Engine," Kelvin rediscovered Carnot, and the Carnot cycle came to be recognised as an ideal criterion of performance which no engine could conceivably surpass. Engineers strove to bring their engines nearer to that standard by compound expansion, by superheating, and by other means of reducing avoidable waste. They also strove to widen the interval between the temperatures at which the working substance took in and rejected heat, for the "heat drop" between these limits determines how much of the supply of heat is ideally capable of conversion into work. Boiler pressures went up and up; they are rising still. A committee of this Institution helped to spread a sound gospel by recommending the Rankine cycle as a basis of comparison with the results of tests, a cycle which differs from that of Carnot only by assuming that no reversible process is followed in the return of the condensed water to the boiler. But it is interesting to notice that modern steam plants of the most efficient type have introduced a reversible process through the device of "bleeding," which enables the

condensate to be heated step by step on its way back to the boiler, in a manner so nearly reversible as to make the whole cycle approximate to the ideal of Carnot.

All this exemplifies the continuous steady pressure of scientific ideas in improving the procedure of the practical engineer. In a different category I would place the invention, by Parsons, of the steam turbine. That, too, was an application of scientific ideas, but it is an example of what I have called a sport. It broke away from established lines, and we may say that in the world of engineering the genius of Parsons opened up a new kingdom. He gave us a power producer, wholly novel in action and design, of greatly augmented efficiency, with a concentration and magnitude of effect never even imagined before.

Another sport was the internal combustion engine. Time would fail me to trace its development from primitive forms; to tell of the steps, big and little, but all essentially scientific, which brought into operation the cycles of Otto and Clerk and Diesel; of the multitude of engines which have turned the man in the street into an engineer, crowding the highways, dotting the seas, and achieving in some sense a conquest of the air.

Reverse a heat engine and you have a heat pump, which means that by expending power from outside you can make a body colder than its surroundings and keep it colder. From this simple piece of thermodynamics has sprung a branch of engineering with immense and growing economic importance. The science of refrigeration offers a conspicuous example of how an industrial process, strikingly novel, may take its origin from an apparently insignificant physical fact, and then repay the debt to pure science by promoting the progress of research. Long ago Kelvin and Joule, in experiments on the properties of gases discovered that when air escapes under pressure through a throttling orifice it undergoes a small drop in temperature—about one-fourth of a degree for each atmosphere. Years afterwards Linde and others, by applying a regenerative interchanger to transfer the cold from the escaping air to the stream that was approaching the orifice so as to obtain a cumulative effect, used this as a practical means of liquefying air, and of separating its oxygen and nitrogen, with the result that each of the two may be commercially utilised. This is now the foundation of more than one considerable industry; moreover, it has given to physicists a new tool of research, enabling them to bring temperatures down to an extreme never before reached in any terrestrial laboratory.

In the region of applied electricity, perhaps more than in any other part of engineering, instances multiply themselves of the exchange of benefits between practice and science. One may, of course, say, with perfect truth, that all the applications of electricity are in their origin fruits of scientific research. If you trace, for example, the history of the dynamo you go back through Hopkinson's formulation of the principle of the magnetic circuit to an experiment of Faraday, which, in 1831, first showed that the movement of a conductor across a magnetic field generates electromotive force. The very language in which one describes this fundamental discovery is language we owe to Faraday himself. From that experiment what a progeny has sprung!

When Kelvin, in 1853, discovered as a piece of mathematical reasoning that under certain conditions as to resistance, self-induction and capacity, a discharge of electricity would be oscillatory, he little knew what he was letting the world in for. From that seed has grown a great tree. The branches, one may say, are visible over many housetops. Through Clerk Maxwell, Hertz, Lodge, Marconi, Fleming, de Forest, and many others, discovery and invention have proceeded, hand in hand, to accomplish what seems to me the most wonderful of all the wonders of applied science. The telephone of Graham Bell, the microphone of Hughes, the phonograph of Edison were arresting marvels whose first coming I vividly recall. But wireless broadcasting still more impresses the imagination. It gives other marvels an added value, and works an even greater social change.

Towards the end of last century, when physical science seemed to some of its votaries to have settled into a groove, suddenly there was an astounding outburst of discovery. The X-rays, radio-activity, the electron—these followed one another in bewildering succession; discoveries wholly unexpected and pregnant with uses to mankind. Each in turn was a revelation to the philosopher; it gave a fresh direction to his concepts of Nature, and it enriched him with novel methods of research. Each of these discoveries also offered an untrodden avenue of practical application. Let me, in the short time that remains, speak briefly of what engineers have done to harness the free electron.

About 1895 Sir J. J. Thomson, examining the discharge which proceeds from the cathode or negative pole of a Crooke's vacuum tube, established the fact that it consists of a stream of separate particles—corpuscles he called them—of negative electricity, independent and all absolutely alike. These corpuscles are now called electrons. Each electron is a definite quantity of disembodied electricity—an irreducible unit—delightfully free to respond to any electric force, for its inertia is barely the eighteen-hundredth part of that of the lightest atom of ordinary matter. Free electrons are known to be given out by highly heated substances, such as the glowing filament in the vacuum bulb of an electric lamp. This fact was turned to account by Fleming in an invention which one may, with no exaggeration, call epoch-making. The Fleming thermionic valve soon came into use as a sensitive detector of wireless signals. Two years or so later its capabilities were much extended by the American electrician, Lee de Forest, who introduced the grid. With this addition the device, now called a triode valve, could be applied as a powerful relay or amplifier, receiving any electrical oscillations and passing them on, greatly magnified. Its technical applications appear to have no bounds. It is also an instrument of research; in the hands of physiologists and others it measures the slightest and most fugitive of electrical effects.

I have cited enough examples to illustrate the broad truth of Tredgold's dictum that the scope and utility of civil engineering are increased by every discovery in natural philosophy. But so sweeping a statement can scarcely fail to have some exceptions, and exceptions are, in fact, suggested by the present curious state of physical science. At the moment the very basis of physics is in a state of flux. Its exponents are struggling to assimilate two momentous new ideas—the principle of relativity and the quantum theory. The relation of these ideas to the familiar body of older physics is obscure. They present dilemmas which are not yet solved. Their exact form and place in the logical scheme of scientific thought has still to be determined. One may say that, while the superstructure remains intact, the philosophical foundation on which it stands is strangely disturbed. Physicists are, as it were, confronted with a difficult but not impossible task; they have to transfer bodily their elaborate and beautifully coherent building, as a going concern, from one foundation to another, and the new foundation is not quite ready. They are hard at work laying it, laying it indeed so deep that the passer-by cannot make out what is going on. When the operation is completed it will be a great achievement. But I do not think it will make much difference to the engineer, for his concern is with the superstructure itself. That will doubtless settle down quite comfortably when the necessary adjustments are made. It will function as well as before, and continue to admit of extensions which the engineers will in due time turn to practical account.

The century we now review is but a petty unit in the multitude of centuries that make up the recorded and unrecorded history of man. By comparison it is a mere fragment of time, yet how big when judged by the changes it has wrought! If you test progress by the conquest of inanimate nature, then the century now closing finds no parallel in the past. It may be likened to the efflorescence of a plant which for long has been quietly growing to maturity and suddenly bursts into flower. We have witnessed as it were the change from bud to blossom. What is to follow? What is left for the future engineer to do? When you celebrate the second centenary of this Institution, of what will your lecturer have to tell? Can the recent astounding pace of discovery and invention be maintained? Can we expect the engineers of the coming century to bring about developments in the application of natural resources comparable to those of the past hundred years? I am, as I said, no prophet, but I doubt it. To me it seems more likely that there will be something of a lull in the revolutionary fervour of the engineer. Social changes—drastic social changes—may be looked for, but not, I think, so directly consequent on his activities as in the century now ending. Mechanical devices will, of course, be increasingly used, but probably they will become standardised and taken for granted, like the watches we carry. We cannot be surprised if we find interest in them slacken. Improvements will be made, but they will attract little notice, for the things they affect will already be commonplaces of life. It may very well happen that the mental energy of mankind, now flowing so strongly in this channel of ours, will seek and find outlets in other directions. While as engineers we may regret such an issue, we cannot but admit that it may prove beneficial to the human race, since, beyond question, there is grave need for progress of quite a different kind.

For the fact remains that all our efforts to apply the sources of power in Nature to the use and convenience of man, successful as they are in creating for him new capacities, new comforts, new habits, leave him at bottom much what he was before. I used, as a young teacher, to think that the splendid march of discovery and invention, with its penetration of the secrets of Nature, its consciousness of power, its absorbing mental interest, its unlimited possibilities of benefit, was, in fact, accomplishing some betterment of the character of man. I thought that the assiduous study of engineering could not fail to soften his primitive instincts; that it must develop a sense of law and order and righteousness. But the war came, and I realised the moral failure of applied mechanics. It was a shock to find that a nation's eminence in this department of intellectual effort did nothing to prevent a reversion to savagery, conscienceless, unbridled, made only the more brutal by its vastly enhanced ability to hurt. I saw that the wealth of products and ideas with which the engineer had enriched mankind might be prostituted to ignoble use. It served to equip the nations with engines of destruction incomparably more potent and ruthless than any known before. We had put into the hand of civilisation a weapon far deadlier than the weapons of barbarism, and there was nothing to stay her hand. Civilisation, in fact, turned the weapon upon herself. The arts of the engineer had indeed been effectively learnt, but they had not changed man's soul. In our diligent cultivation of these arts we engineers have perhaps forgotten that progress in them has far outstripped the ethical progress of the race. We have given the child a sharp-edged tool before he has the sense to handle it wisely. We have given him the power to do irreparable mischief when he hardly knows the difference between right and wrong. Does it not follow that the duty of leadership is to educate his judgment and his conscience? Collective moral sense, collective political responsibility, the divine maxim to do to others as we would that they should do to us—these are lessons in respect of which all the nations, even the most progressive, have still much to learn.

Surely it is for the engineer as much as any man to pray for a spiritual awakening, to strive after such a growth of sanity as will prevent the gross misuse of his good gifts. For it is the engineer who, in the course of his labours to promote the comfort and convenience of man, has put into man's unchecked and careless hand a monstrous potentiality of ruin.

The Geometry, Wear and Testing of Safety Razor Blade Edges.

By J. FERDINAND KAYSER, Assoc. Met.

Of all the cutting implements known to our civilisation, a safety razor blade is probably conceived on the smallest scale and has an edge whose sharpness is not exceeded even by that of a surgeon's lancet. In spite of its diminutiveness, the edge has a well-defined geometry, and unless the cutting angle is suitable and the cutting edge free from imperfections the best hardened blades will not function satisfactorily.

In his "Micrographia," published in 1665, Dr. Hooke gave a drawing of a razor edge which, from references in the text, appear to be magnified fifty-five times. Desch and Roberts[1] and Kotaro Honda and Kinnoske Takahasi[2] in papers read before the Iron and Steel Institute, briefly referred to certain aspects of the cutting edges of razors, but did not attempt any detailed investigation. With the exception of his own paper, read before the Sheffield Society of Engineers and Metallurgists[3] in November, 1925, the author has been unable to find any other publications devoted to a consideration of the edges of safety razor blades.

During the last few years the present writer has examined and tested several hundred razor blades made both in this country and abroad, and, in the course of the present communication, it is proposed to describe and illustrate the various types of cutting edges encountered and the *modus operandi* of wear. None of the blades examined were specially prepared, but were purchased from retailers. In every instance, at least twelve blades from one source, and of one and the same type were examined, and finally used for shaving purposes.

One type of safety razor blade is almost identical to a hollow-ground long razor, in so far as cross section and geometry of cutting edge are concerned, and it is illustrated by photographs Nos. 1 and 2 at 2¾ and about 22·2 diameters respectively.

The majority of safety razor blades are, however, manufactured from cold rolled strip and are ground and finished after being hardened and tempered. The thickness of the strip varies from six-thousandths of an inch to twenty-thousandths of an inch, according to the type of blade. Methods of producing the edge vary, but, whatever the exact process adopted, it can usually be roughly divided into the following three operations:—

(i.) Rough grinding by means of an emery wheel.

(ii.) Finish grinding by means of a very fine-grained emery wheel, or by means of hardened and polished steel wheels dressed with a preparation of stearine and chromium sesqui-oxide.

(iii.) A final stropping process.

When examined at a very low power, say, not more than 10 diameters, all safety razor blades appear to have a similar cutting edge, which, in the majority of cases, seems to be formed by the intersection of two plain flanks. A more detailed examination at various magnifications, from 15 to 400 diameters, shows, however, that cutting edges vary greatly, and it is possible to place them in one of four classes, which, generally speaking, remain sharply defined.

Types of Cutting Edge.

The simplest form of cutting edge is formed by the intersection of two plain flanks, as illustrated in the

[1] *Journal* of the Iron and Steel Institute, 1923, No. 1, page 249.
[2] *Journal* of the Iron and Steel Institute, 1927, No. 2, page 357.
[3] *Journal* of the Sheffield Society of Engineers and Metallurgists, 1925, No. 2, page 11.

drawing, Fig. 1. The microscopic examination of blades with such a cutting edge presents no difficulties to even an unskilled microscopist. A typical example of a good edge of that type is illustrated in photographs Nos. 3, 4 and 5, at about 7·4, 22·2 and

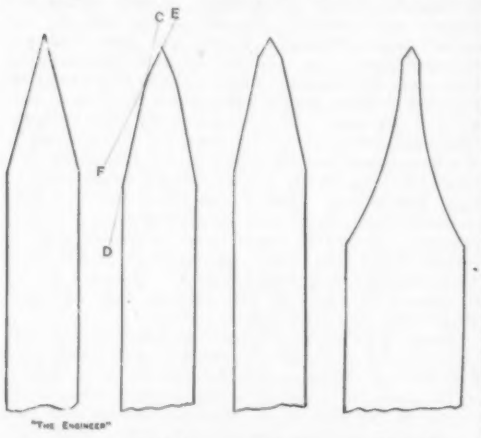


FIG. 1 FIG. 2 FIG. 3 FIG. 4

148 diameters magnification respectively. The included angle of the cutting edge is usually about 18 deg. All blades of this type have, however, by no means so perfect a cutting edge, and that is well illustrated by photographs Nos. 6 and 7, each of which has a magnification of about 37 diameters, and neither of which edge would give one shave.

The majority of safety razor blades have a cross

PHOTOGRAPH NO. 1

section of the type illustrated in the drawing, Fig. 2. Unless care is taken in mounting them for examination most fictitious results can be obtained at some magnifications. If a "cover slip" or a "prism" vertical illuminator is used and the blade so mounted that the plane C D is at right angles to the optical axis, an appearance similar to that shown in photograph No. 8—magnification about 37 diameters—is obtained. If, however, the blade be so inclined that the plane E F is at right angles to the optical axis, then only does one obtain a photograph of the true cutting edge, as illustrated in photograph No. 9—magnification about 37 diameters. Photographs Nos. 10, 11 12 and 13 illustrate a good edge of this type at about 7·4, 22·2, 148 and 296 diameters respectively.

Razor blades with an edge as illustrated in the drawing Fig. 3 are more seldom encountered. A typical example is illustrated by photograph No. 14 at about 22·2 diameters magnification. The true nature of the cross section is, however, not obvious from that photograph, but is clearly shown by photograph No. 15, also at about 22·2 diameters magnification. Photograph No. 16 shows the extreme edge at a magnification of about 296 diameters. In this particular case, the actual cutting angle was approximately 18 deg., whilst the two secondary flanks were inclined to one another at an angle of 10½ deg. In spite of the rarity of this type of edge, the writer has found that it is always remarkably uniform, and the blades shave smoothly and have a reasonably long life.

The drawing, Fig. 4, illustrates a further type of edge, which is said to be "hollow-ground." Whilst it is true that the secondary flanks are concave, the term "hollow-ground" is misapplied, as, in the razor trade, it is used to describe razors with cross sections similar to that illustrated in photograph No. 1. The blades with this type of edge, which were examined, proved to be far from uniform. That is well illustrated by photographs Nos. 17, 18 and 19, all at about 11 diameters magnification.

"WORK" DONE IN SHAVING.

Before describing the *modus operandi* of the wear of safety razor blades, it is interesting to consider the work which each edge has to perform before being discarded or re-stropped. The average shaving area of a normal-sized man is of the nature of 250 square centimetres. The distribution of hair over that area varies in different individuals, and also in one and the same individual. A concentration of 100 hairs per square centrimete is, however, as high as is ever met with, *i.e.*, a total of 25,000 hairs to be cut per shave. Assuming that individual hairs have a circular cross section of 0·01 centimetre diameter, and that 25,000 were packed together as illustrated in the drawing, Fig. 5, the area of the cross section they would occupy would amount to 2½ square centimetres, say, 50 mm. by 5 mm. After numerous observations of shaving times and assuming a distribution of 100 hairs per square centimetre and a total length of cutting edge of 5 centimetres, the total time during which the edge is actually cutting through hairs has been found to be of the nature of five seconds. The edge of a good blade does not on an average ever give more than ten clean shaves, and hence its useful cutting life is only 50 seconds. The rate at which a razor traverses the face is of the nature of 20ft. to 40ft. per minute.

There are so many variables in shaving that the above figures must be used with caution, but for the present they are put forward as a concrete example of the approximate amount of "work" a razor edge is called upon to perform. In the majority of cases safety razor blades are discarded when blunted, but certain types can be stropped readily, and the edge continually renewed.

COMPOSITION AND MICROSTRUCTURE.

The majority of safety razor blades are made from straight carbon steel containing 1·1 to 1·3 per cent. carbon. One of the makes of blade examined was, however, made from a high alloy steel of the following approximate analysis:—C, 1·35 per cent.; Si, 0·8 per cent.; Cr, 12·0 per cent.; Mo, 1·0 per cent.; Co, 1·1 per cent.

The microstructure of the plain carbon steel blades consists essentially of globular cementite embedded in a structureless matrix. The size and distribution of the cementite globules varies greatly. A typical example of the structure of a good blade at about 296 diameters is shown in photograph No. 20. The edge there illustrated had been used five times and was still in good condition and gave a further five clean shaves. Photograph No. 21 at the same magnification illustrates the structure of another blade, which had to be discarded after two shaves. The structure in the above two cases was developed by etching in 2 per cent. nitric in alcohol for one minute.

The blades made from the high chromium steel show a somewhat analagous structure, but the matrix appears to be sorbitic and the non-etching carbide corresponding to the cementite of the straight carbon steel blades has not a pronounced globular structure, and is not as uniformly distributed as is the cementite in the carbon steel blades. A typical structure developed by etching in 10 per cent. nitric in alcohol

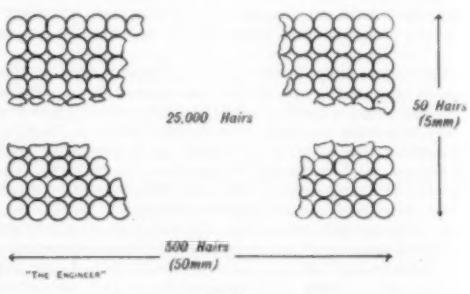


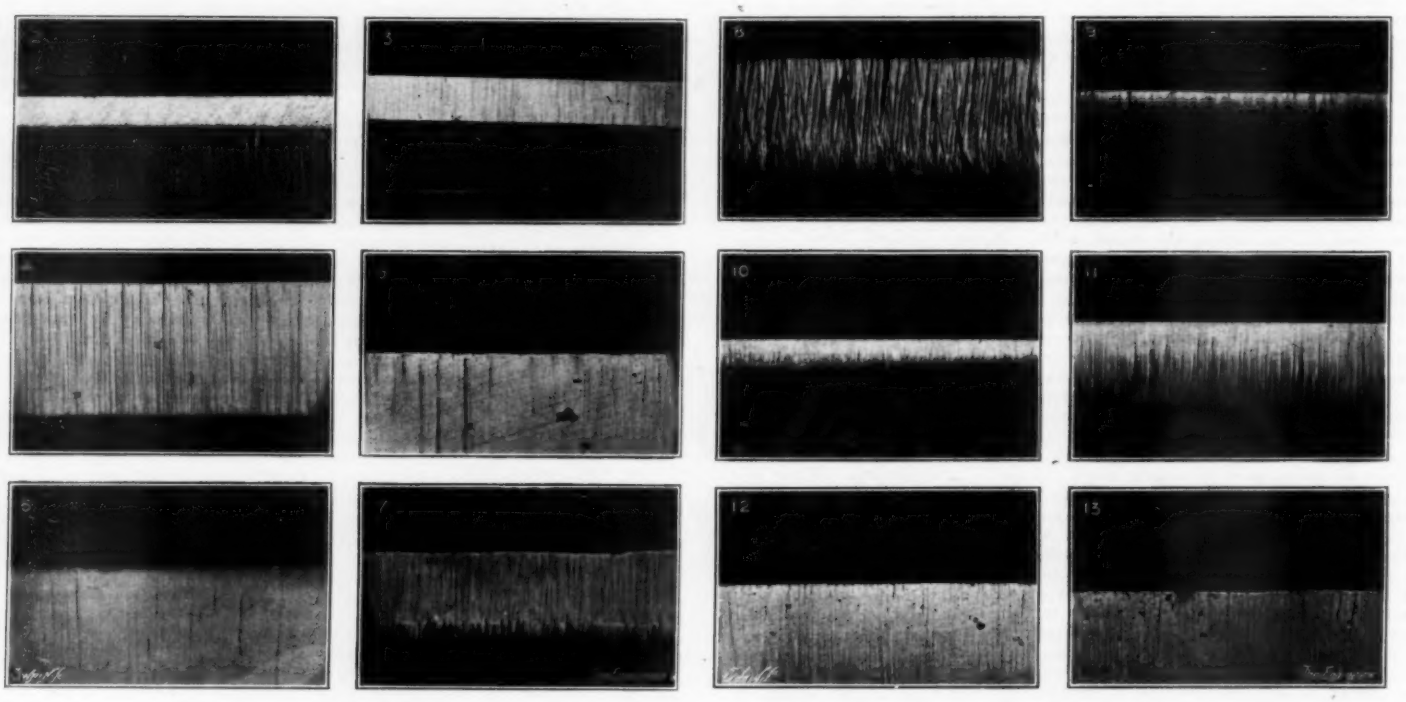
FIG. 5

for ten minutes is shown in photograph No. 22 at about 296 diameters. The particular edge photographed had given approximately fifteen shaves, but then dragged badly.

WEAR OF SAFETY RAZOR BLADES.

The study of the wear of cutting edges is complicated by the fact that a blade which will no longer shave one individual may function quite satisfactorily when used by another with a beard of different texture. At one time, when the writer was testing blades made from chromium steel of the analysis previously mentioned, he found that, whilst he had to discard average blades after approximately fifteen shaves, another person with a much stiffer beard could continue to shave with them for at least another fifty times.

Photograph No. 23 at about 296 diameters magnification illustrates a defect in a blade which had worn to such an extent that it was found to drag uncomfortably. Another part of the same edge, after etching in 2 per cent. nitric acid in alcohol, is illustrated in photograph No. 21, to which reference has been previously made. Although it is not very clear in the photograph, visual examination through the microscope showed that, in general, globules of cementite projected from the cutting edge exactly as described by Desch and Roberts,[1] who suggested that the property of keeping an edge depended upon the size and uniformity of distribution of the particles of cementite.



PHOTOGRAPHS 2 TO 7 PHOTOGRAPHS 8 TO 13

There is no direct evidence that the cementite globules in a properly hardened razor blade blank are sensibly harder than the matrix, and it is unlikely that the action of shaving would erode the latter and leave the cementite projecting from the edge. At least 50 per cent. of the blades examined were found to shave satisfactorily, and yet the size of the cementite globules and their distribution varied considerably, even in blades from the same source. Without exception, however, good safety razor blades exhibit a perfect edge at 400 diameters and have a Firth Diamond hardness of 650 to 800.

Wear never takes place uniformly along the edge. In the case of a good blade, one usually finds that the edge remains more or less perfect for the first few shaves—see photograph No. 20—and then commences to break down in patches, such as are illustrated in photograph No. 23. Finally, the whole edge tends to disintegrate, leaving cementite globules projecting, and in some parts developing pits. Careful examination of many hundreds of blades has shown that the cutting edge of a normally hardened blade does not show the slightest tendency to become rounded or wavy. In fact, the chief destroying agent seems to be corrosion. The finish which the final stropping process gives to a cutting edge is such a perfect polish that corrosion can be resisted for a considerable time, but if once the edge becomes damaged, either while shaving or being dried, a small freshly fractured surface is exposed, from which corrosion might be expected to extend and produce the type of defect illustrated in photograph No. 23. That suggested explanation of the cause of failure is supported by the fact that if, instead of wiping a razor after use, it is kept in an anti-corrosion liquid, its life is usually at least doubled. It is also further supported by the fact that the chromium steel blades, previously mentioned, which are more or less stainless, give remarkably long lives.

The chromium steel blades wear differently from a carbon steel blade, in that, in those examined, the carbide particles have not been found to project from the cutting edge, but rather appear to have fallen out. Whatever the exact *modus operandi* of wear, the mechanical result is, nevertheless, the same, whatever the composition of the steel, and the question as to whether a properly hardened blade will shave depends partly upon the geometry and condition of its cutting edge and partly upon the texture of beard to which it is applied.

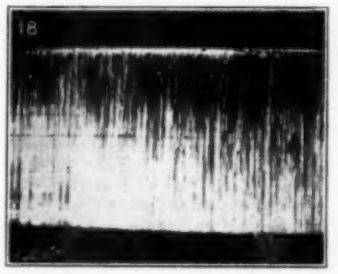
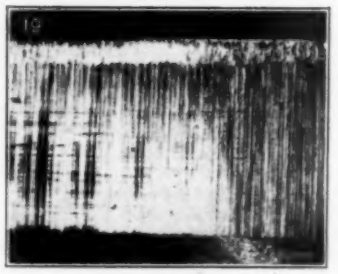
Use of the Microscope to Control Production.

Whilst numerous good blades are procurable, it is obvious that many manufacturers do not control their product microscopically, otherwise blades similar to those illustrated in photographs Nos. 6, 7, 17, 18 and 19 would never be allowed to leave the works. A magnification of from 15 to 30 diameters already shows a very great deal, and it should not be impossible, even in factories producing hundreds of thousands of blades per week, to examine a considerable percentage at some such magnification. The smallest defects which will render a blade useless are not apparent at less than 200 diameters, and the present writer prefers to use 400 diameters magnification. In the case of a new blade, however, it will be found that if the cutting flanks and edge appear uniform and free from defects at 30 diameters, the blade will be as well ground and finished as is possible with the particular machines in use.

Testing of Safety Razor Blades.

Safety razor blade makers are faced with the same problems which confront the manufacturer of high-speed tools and other cutting implements when they desire to test their product. It is a comparatively easy matter to measure the initial "sharpness," but it is quite another matter to measure the cutting durability and to obtain a figure of merit which will be a true criterion of shaving efficiency.

In the paper by Honda and Takahasi,[2] previously referred to, a sharpness testing machine is fully described. In that test, to quote from the original paper, "the cutting edge of the implement is brought into contact, under a definite pressure, with a narrow band, composed of sheets of paper about an inch in thickness, and a definite amount of forward and backward motion is given to the implement. The number of sheets cut during this motion is taken as a measure of the sharpness of the implement." A table is given showing the sharpness of various cutting implements, including a safety razor blade after the first, tenth, twentieth, fiftieth and hundredth cut. The number of cuts required to reduce the initial sharpness to half its value was defined as the life or the durability of the edge under test. According to the figures given, a safety razor blade cut through eighty-five sheets of paper at the first cut, and its durability was found to be 3·5.

PHOTOGRAPHS 14 TO 19

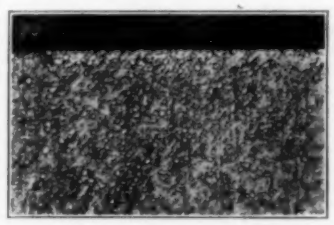
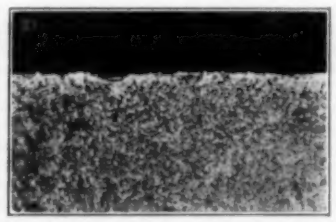
At one time the writer contemplated making a somewhat similar machine, but found that a safety razor blade was completely ruined long before it had passed through anything like the number of sheets of paper quoted by Honda and Takahasi, as the number parted at the first cut. Unfortunately, the type of paper used in the original tests is not mentioned, but the author found that a blade which had been used to cut through fifty pages of the present journal would not shave at all.

In the discussion on the aforementioned paper, Dr. Kurek and Mr. Knapp described an apparatus by Professor Thunberg for determining "cutting capacity" as opposed to "durability." Dr. Kurek and Mr. Knapp state: "Thunberg uses threads of a known strength and determines first the value O for the load which is necessary under a non-cutting pressure—produced by a thin round bar—to break the loop, and then the value P for the corresponding load under a cutting pressure, applied with a knife edge. The degree of sharpness is expressed by the formula—

$$A = \frac{O - P}{P}.$$

The present author tested a number of blades by a somewhat similar method, but found that many blades which appeared to have great cutting capacity and would cut thread after thread without any increase of pressure, would not shave smoothly.

So far as our present knowledge goes, it hence appears that the only satisfactory test for a safety razor blade is an actual shaving test, and as shaving is carried out so quickly and willing assistants who are prepared to test blades are always to be found on any works, good progress can be made without any special testing machine, although one would, of course, be desirable in order to put production on a really scientific basis. In many factories it is the custom to test each individual edge, the test usually consisting of a test of cutting capacity. A hair is held between the thumb and finger of the left hand with one free end, and all edges must snip the hair cleanly when flicked across it. Satisfactorily hardened blades should also pass the same test after being pulled over a piece of soft horn with a pressure which is something of the nature of 25 to 50 grammes, the actual length of cutting edge bearing on the horn varying from 2 to 5 millimetres. Those figures must not be taken too seriously, but are some rough idea of the nature of a test which is largely adopted.

PHOTOGRAPHS 20 TO 23

SIXTY YEARS AGO.

"It is to the last degree unlikely that as much progress will be made during the last half of the present century as marked its first fifty years." So we find it written in a leading article entitled "The Impossible in Constructive Science," which appeared in our issue of June 5th, 1868. Many roads yet remained to be explored, and progress of some kind, we admitted, was certain to be made. But the more our knowledge extended, the more evident did it become that walls apparently of adamant stood between us and farther progress in certain directions on the great highway of science. Great discoveries might yet be made and magnificent inventions produced, but it was very unlikely that either discovery or invention would ever again be given to a civilised people which could add to their comforts or promote their wealth or happiness as greatly as past inventions and discoveries had blessed our country. It would be unprofitable and unsatisfactory to debate whether our prophecy has been fulfilled, for who can assess the relative comfort, happiness or wealth produced by any two given inventions? When we wrote in 1868 the high view which we took of the achievements of the past and the discouraging outlook which we expressed regarding the possibilities of the future were inspired largely by the discovery of the conservation of energy, as a result of the recent researches of Grove, Faraday and Joule. That discovery, we wrote, had dashed the hopes of inventors to the ground. It had shown that no better way of producing power would ever be realised than by means of the steam engine allied with the combustion of coal—or, more generally, with the combustion of carbon and hydrogen. Neither the engineer, nor the chemist, nor the electrician could, we stated, help mankind to anything much better than the child of James Watt's brain. In explanation of our remarks it is necessary to recall that before the doctrine of the conservation of energy was established, many people looked to certain electrical phenomena as a means of obtaining power without the use of a steam engine or the combustion of fuel. The conservation of energy theory, however, showed that the power obtained from an "electro-magnetic motor" could not exceed the thermal energy of the fuel used to reduce zinc oxide to the metallic state in which it was used in the batteries supplying the motor. Similarly, it showed that the all but frictionless electrical induction machine opposed when it was running a resistance to the force driving it, and that it was merely a means of transmuting mechanical into electrical energy. Passing to other illustrations of the fact that we had reached nearer to the impossible than many were inclined to believe, and that progress was becoming more difficult each year, we commented on the obstacles which stood in the way of increasing the speeds realised on railways and by ships. We were, we said, as near travelling at a hundred miles an hour in a train as we were before Stephenson was born. At sea we could not drive a ship at 30 miles an hour, and there was no reason to believe that we ever would be able to do so. There were limits to man's progress which he could not pass. What those limits were in the case of railway speeds we did not indicate, but in the case of ships we left our readers in no doubt. No combination of wood or iron, we said, could sustain the strain necessary to impel a ship, sufficiently large to carry the coal and engines required for the purpose, across the Atlantic in three or four days.

The expansion programme of the aluminium industry is so extensive that a period of unusually severe competition would seem to be ahead. The world production in 1927 is reported as about 450,000,000 lb. of primary aluminium, of which the United States contributed about 160,000,000 lb. The plant of the Aluminium Company of America now under construction at Chute-à-Caron on the Saguenay River in Canada will be the largest in the world. Other plants have recently come into operation in several European countries, while new construction is contemplated or under way in Italy, France, Norway, Poland, Japan and elsewhere.

H

The Institution of Civil Engineers' Centenary Celebrations.

No. I.

IN befitting manner, the Institution of Civil Engineers this week celebrated the centenary of its incorporation by Royal Charter, by the reception of delegates and by a conference at which numerous papers were presented for discussion. The celebration opened with a service in Westminster Abbey on Sunday afternoon, June 3rd, when Dean Inge preached. It was followed on Monday morning, June 4th, by a meeting in the Great Hall of the Institution, where the President, Mr. E. F. C. Trench, welcomed delegates, who then presented congratulatory addresses. There were present representatives of no fewer than ninety-seven engineering and scientific societies and universities from all parts of the world.

In opening the proceedings, the President proposed that a loyal address to the King should be sent from the Conference, a suggestion which was received with hearty applause. The following are the terms of the address sent:—"The members of the Institution of Civil Engineers and the representatives of engineering societies throughout the British Dominions assembled to-day to celebrate the one-hundredth anniversary of the incorporation of the Institution by Royal Charter on June 3rd, 1828, humbly beg leave to convey to his Majesty the King their respectful congratulations on the completion of sixty-three years of a life devoted to the service of the nation and the Empire. They appreciate very gratefully the interest which his Majesty and the members of his Royal House have always taken in those works which it is the privilege of engineers to carry out and on which the welfare, prosperity, and safety of the Empire depend. It is their earnest prayer that his Majesty may long continue to wield over the Empire that beneficent rule which has gained for him the devoted loyalty and deep affection of all his subjects. The delegates from other British learned and scientific societies and universities and from foreign engineering societies assembled on this occasion beg leave respectfully to associate themselves to this greeting to his Majesty."

The President then offered a hearty welcome to the delegates from kindred societies all over the world and from universities of the Empire, who had come to join in celebrating the one-hundredth anniversary of the incorporation by Royal Charter of the Institution, and reviewed shortly the principal stages in the history of the Institution. He pointed out that the need for better facilities for the interchange of opinions upon questions involving the application of scientific principles in engineering practice was acutely felt by the eight original members of the Institution. They might not all have been great engineers but their names deserved to be remembered for all time, for they laid the foundations not only of the Institution, but of daughter institutions in this country and in the Empire beyond the seas. They were James Ashwell, Charles Collinge, Joshua Field, James Jones, John Thomas Lethbridge, Thomas Maudslay, William Maudslay and Henry Robinson Palmer.

The first meeting took place at the Kendal Coffee-house in Fleet-street on January 2nd, 1818, and meetings were regularly held at that place and at Gilham's Coffee-house until 1820, when rooms were hired in Buckingham-street, Strand. In 1824 the meeting place was removed to Cannon-row, Westminster, and four years later the Institution obtained its first home in Great George-street, where in different buildings its headquarters have ever since been situated. In 1820 Thomas Telford became the first President. He held that position for fourteen years, and during that period the constitution of the Institution was formulated and its activities took definite shape. The first Charter was granted on June 3rd, 1828, and it was not a little remarkable, said the President, that at that early date it should have been possible to find a form of words, so adequate and so comprehensive, to describe the work of the civil engineer, and that those words should, in spite of all developments and discoveries of science, be still a complete description of the work of the profession. In the words of the Charter, the Institution was founded for the general advancement of mechanical science and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a civil engineer, being the art of directing the great sources of power in Nature for the use and convenience of man. That still remained a true description of the purpose of the Institution which was formed by men who were mainly mechanical engineers, but they were soon joined by others engaged in the construction of roads, bridges, canals and docks. It was not intended to be, nor was it, a sectional society, but was wide enough in its constitution to embrace all branches of the engineering profession except military engineering.

Remarking upon the manner in which the Institution had fulfilled the aims and achieved the purpose for which it was founded, the President pointed out that whereas a hundred years ago the membership was 156, it was in May of this year 10,210, and in round figures 7000 members were in Great Britain and Ireland and 3000 abroad. The address then went on to detail the work of the Institution through its fortnightly meetings for the reading and discussion of papers, the work of its committees, the initiative taken by it in the formation of the Engineering Standards Committee, the qualifications for membership, and the care taken to ensure that only properly qualified men obtained admission to the various degrees of membership.

The question of the legal regulation of the civil engineering profession, continued the President, was one of considerable difficulty and complexity, discussion of which was not infrequently clouded by assumptions of complete analogy between the engineering profession and professions whose members are brought into more intimate personal contact with individual members of the general public in the ordinary exercise of their professional duties. Whatever developments in that respect might take place in the future, however, might be awaited with equanimity by a body of engineers which was constantly doing its utmost to ensure the highest possible qualifications on the part of its members, and it was also clear that persons who possessed such qualifications had a *primâ facie* title to be regarded as the most suitable source from which to draw, at all events, those engineers who were responsible for the expenditure of public money on engineering work. The Institution had taken steps from time to time to bring that consideration before the notice of the proper authorities. Its representations had, in general, been sympathetically received, and its views on that question were becoming accepted and acted upon. For the present, however, as the late Sir James Inglis said in his presidential address, "Our primary object is to make the Institution strong and efficient in the promotion and dissemination of engineering knowledge and thereby to advance the status of engineering as a profession."

The success of the Institution and the advantages derived from membership had had the natural result of encouraging the formation of other engineering societies. They were now very numerous; some had their headquarters in London, some in different provincial centres, and some in distant parts of the Empire. The Institution recognised that with the vast expansion of engineering work it was impossible for one institution to give to every branch of the profession all those opportunities for friendly intercourse and for the intimate discussion of the details of its own professional work which were so valuable and necessary. All were helping to spread the light of engineering knowledge, and in that good work the Institution of Civil Engineers desired heartily to co-operate. That attitude, it was believed, did not involve any departure from, nor was it desired in any way to depart from, the decision adopted by the founders of the Institution and formulated in its Charter.

From that short description of the Institution's constitution and aims, and its activities in the advancement of mechanical science, it would be evident, concluded the President, that it took a wide view of the profession of a civil engineer and endeavoured to fulfil the functions of a representative and co-ordinated body, not only by admitting to its ranks engineers in all branches of the profession, but also by seeking to advance engineering knowledge of all kinds. That its efforts in that direction were appreciated, and its policy endorsed, was shown by the fact that prominent engineers, not only in this country, but also abroad, sought membership of the Institution, and regarded that membership with pride. In the future as in the past, there would be welcomed to the roll of members all those who by their training, experience, engineering skill and probity of character were prepared to maintain the highest traditions of the great profession of civil engineering.

The presentation of Addresses of Congratulation and Goodwill by the delegates was then proceeded with. The President, however, called attention to the obvious fact that it would be impossible to read all of them. A few had been selected, but he assured the other delegates that it was through no want of courtesy or lack of appreciation of the sentiments contained in their Addresses that they were not being read.

The delegates of nine institutions or universities were actually called upon to read their Addresses, but two did not put in an appearance. Sir Richard Glazebrook, F.R.S., representing the Royal Society, came first, and was followed—in the absence of the delegates from the Royal College of Physicians and the Law Society—by Professor C. E. Inglis, representing Cambridge University. Then came Mr. Allen Hazen and Mr. George T. Seabury, representing the American Society of Civil Engineers; Monsieur de Chasseloup Laubat and Mr. Frank Merricks, representing the Société des Ingenieurs Civils de France—the former read the Address in French—Mr. David Lyell and A. C. Macdonald, representing the Engineering Institute of Canada; Mr. R. W. Allen, representing the Institution of Mechanical Engineers; Sir John Biles and Engineer Vice-Admiral Sir Robert B. Dixon, representing the Institution of Naval Architects; and, finally, Mr. A. Page and Dr. W. H. Eccles, F.R.S., President and past-President respectively of the Institution of Electrical Engineers.

Then followed a reception by the President of the remaining ninety or so delegates, and the ceremony came to an end with a cordial vote of thanks to the delegates, which was proposed by Sir Alexander Kennedy, the senior Vice-president. In addition to representatives of engineering and allied institutions and the scientific societies in Great Britain and the Dominions, delegates attended from Austria, Chile, Czecho-Slovakia, Denmark, France, Germany, Holland, Italy, Japan, Norway, Portugal, Sweden, Switzerland, and the United States of America.

THE CONFERENCE.

The Conference proper was opened on Tuesday morning, June 5th, by the President of the Institution in a short address, in which he stated that before the war the organisation of engineering conferences was looked upon as one of the regular and normal activities of the Institution, but that only one had been held in the intervening years, namely, in 1921. On the occasion of the Centenary celebration, however, it seemed appropriate that civil engineers should once again meet to review the progress made in recent years, to discuss questions of special interest at the moment, to pool their accumulated knowledge and to explore every road which seemed likely to lead towards engineering progress in the future. The field of engineering knowledge was widening every day, and engineers tended to become specialists, concerning themselves only with their own limited activities. This tendency to work in water-tight compartments, however, even if inevitable, was to be regretted. Great progress was being made in many branches of scientific and industrial research, by chemists, metallurgists and physicists, and the heads of many industrial concerns were realising that it was only by keeping abreast of the latest discoveries of science and spending money on research that they could successfully compete with their rivals abroad. The same was true of engineering work. Great strides had been and were being made in certain directions, and engineers would handicap themselves if they did not keep themselves informed of what was being done in other spheres of work. He therefore suggested that members of the Conference should not confine their attention too exclusively to the work in which they themselves were specialists, but should, if at all possible, find opportunity for attending meetings of sections other than those in which they practised. In former days, when almost the whole of engineering knowledge could be absorbed by one head, the engineer was a man of very wide interests and sound common sense, whose advice was sought on many subjects quite unrelated to his professional work. Nowadays the tendency seemed to be to look on the engineer as a kind of special tool useful for building dams or docks or dynamos, but less useful as a citizen. That might be partly their own fault, for engineering was an absorbing occupation which left little time for other activities. The tendency, however, was not one to be encouraged if the engineer was to take his proper place as a citizen of the world, capable, by reason of his training, habits of thought and knowledge of men, of filling with credit the most responsible positions which the community had to offer. There was no better way in which engineers' interests could be enlarged, and their horizon widened, than by attending and taking part in a Conference such as that.

The members and delegates then dispersed to take part in the various sectional meetings. In all cases the papers were very short and were taken as read, so that all the available space might be devoted to the discussion. In our reports of the meetings we give, first, abridgements of the papers and then summaries of the discussions.

IN THE GREAT HALL OF THE INSTITUTION.

Mr. Basil Mott presided during the reading of the first paper in this section.

RECENT DEVELOPMENTS IN CONCRETE AND CEMENT FOR ENGINEERING STRUCTURES.

BY FRANCIS ERNEST WENTWORTH-SHEILDS, M. Inst. C.E.

The past decade has seen some notable extensions of the usefulness of cement and concrete. As regards the former, there has been a remarkable increase in the demand for, and the supply of, rapid-hardening cements, of which perhaps the foremost is that known as "fused cement (*ciment fondu*), which was first produced at the works of Lafarge in France. It was discovered during a search for a cement which would resist the destructive action of sea water or other water containing sulphates. In this respect it bids fair to be successful, for ordinary Portland cement while setting liberates hydrated lime, which combines with the sulphates to form bulky and non-cementitious—and consequently disruptive—compounds. On the other hand, fused cement produces no lime, and is therefore free from this source of destruction. Incidentally, it was found that the cement, while slow-setting, hardened rapidly and became much stronger than ordinary Portland cement. It was also found that concrete made with this cement had a comparatively high impermeability and heat resistance.

Its invention seems to have produced a demand for rapid-hardening cements of moderate price, which has been met by the manufacture of very finely ground Portland cement, of which "Ferrocrete" is typical. The makers of this cement guarantee that their product shall pass all the British standard cement tests, and, in addition, that 3-to-1 sand briquettes shall bear an ultimate stress of 300 lb. per square inch when one day old, and 550 lb. per square inch when seven days old. They also undertake that the residue on a sieve of 180 by 180 meshes per square inch shall not exceed 1½ per cent. This type of cement is becoming very popular.

A cement which will most probably be durable in sea water is Portland blast-furnace cement, of which a fair quantity is made in Scotland, and for which a British standard specification was issued in 1923. The admixture of blast-furnace slag seems

to combine with the lime freed during setting and to render it harmless. Many authorities consider that some substance of the kind containing silica in "soluble" form ought to be added to all Portland cement used in sea water. Trass and pozzolana are, of course, much used on the Continent in this way, and, in addition to slag, burnt clay has been suggested.

As regards concrete, much interest has been aroused in the researches carried out at the Lewis Institute at Chicago under Professor Duff A. Abrams, who has investigated the question of how to produce a concrete of required strength with given aggregates at minimum cost. His investigations have thrown much light on the effect on strength of three variables, namely (1) the proportion of water to cement, (2) the size and grading of the aggregate, and (3) the proportion of aggregate to cement.

Another concrete research of great interest has been made lately by Dr. Oscar Faber, M. Inst. C.E., who has found that the permanent shortening—plastic yield—of concrete under compressive stress is additional to and exceeds the shortening due to shrinkage, and that it increases with the stress and also increases with time—more rapidly at first, but continuing for many weeks.

The use of reinforced concrete for piles increases daily, partly on account of the difficulty in obtaining timber in long lengths, and partly because of its liability to attack—especially in sea water. In spite of their great weight, it has been found possible to make and drive very long piles of this material—for example, at the Manills Wharf, where piles, 110ft. long, 24in. square, and weighing 28 tons, were driven by a double-acting steam hammer, weighing in all 13 tons.

Sir Alexander Gibb agreed with regard to the importance of the proportion of water, size and grading of aggregate, and the proportion of aggregate to cement, but said, surely the results of Professor Abrams' investigations depended on what was meant by the mixture being "workable." As to the proportion of water, the best concrete was one which was like porridge, so that it would flow down and drop into place, forming an absolutely solid mass. He did not think it was possible to lay down a hard-and-fast rule as to the amount of water to be put into concrete, because so much depended upon the conditions of the materials and the weather.

Sir Owen Williams suggested that the reason why too much water was very frequently used in mixing concrete was that the materials were expensive, whereas water was extremely cheap.

Dr. W. Lowe-Brown remarked that Professor Duff Abrams had in effect said that if contractors only bothered about the water they need not pay any attention to the cement and sand, but he had added several provisos, which rather did away with the striking nature of his remarks, by saying that the concrete must be workable and that there must be sufficient cement for the particular aggregate being used. The difficulty with the cement-water ratio was in its application, and that was confirmed by the fact that, although the theory had been known and well advertised for ten years, it had not been adopted even in the land of its birth except spasmodically, and when it had been used there was no indication that it had proved so satisfactory that other people had immediately rushed to follow the example. With a good old-fashioned inspector who would look after the work thoroughly contractors could dispense with many of the modern ways of getting an exact consistency. When less experienced inspectors had to be relied upon the addition of a slump test was advisable in the interests both of the work and of the contractor.

Mr. F. A. Wilson said that although a great deal was heard of the necessity for elaborate calculations in obtaining a satisfactory concrete, the practical fact was that things had to be taken as they were on the job. The size of the aggregate would vary, unless the trouble was gone to of crushing everything to gauge, which would add greatly to the cost. Then the materials had to be dealt with dry on some occasions and wet on others, and therefore a great deal had to be left to the judgment of those in charge. He had put up thousands of yards of concrete, working solely by judgment, and had obtained just as good results as if an elaborate system of calculation and gauging had been adopted. It was very difficult to swallow the suggestion that it did not matter what material was used as long as there was the right proportion of water. In his view, the strength of a concrete must depend on the cement and varying the proportion of water, and he did not think engineers had yet arrived at the time when the only thing to consider was the amount of water.

Major R. A. Smith said that the results of the Institution of Civil Engineers' own Committee's investigations showed that if proper precautions were taken it was possible to get as strong a structure with Portland cement as with aluminous cements. There were definite reasons for the use of rapid-hardening cements, beyond those mentioned by the author, and the principal one was that a denser and more close concrete was obtained. Professor Abrams' researches were extremely valuable and rather suggested the appointment of a committee to decide whether specifications in the future should demand from the contractors concretes of a definite strength.

Mr. H. A. Reed, referring to experiments with ciment fondu, said it was important that the mixture should be thoroughly flooded when made, and in the case of piles he kept the tops flooded for six hours and then covered them with sacks and kept them wet until set. For some years he had been making experiments with regard to the slump test, and although good results were obtained in the laboratory with dry materials, it was not a commercial proposition to use a dry concrete. As a matter of fact it was all a question of using common sense and putting in sufficient water which would allow the concrete to get round the bar with a reasonable amount of punning.

Mr. R. H. Stanger remarked that he did not see the need for aluminous cement on road work, as ordinary Portland cement set quickly enough to keep pace with the workmen. The slump test was valuable, if contractors could be got to use it, because at the present time it was possible to get differences of from 2000 lb. to 6000 lb. on different batches from one mix, and large differences were often obtained from different mixes ostensibly the same.

Professor S. M. Dixon expressed the view that the curing of cement and the seasoning of concrete were as important as testing. Commenting on the fact that engineers had been looking for many years for a light concrete for roofs and walls, Professor Dixon referred to "Aerocrete." It was made, he said, by adding finely divided aluminium powder to the cement, which had the effect of generating oxygen and hydrogen, which, bubbling through the material, caused it to rise and, when set, leave a bulky aerated concrete, which, however, was extremely strong, crushing strengths of from 400 lb. to 1000 lb. per square inch being obtained. That material was being used in large quantities in Norway, Sweden, and Denmark, where great advances had been made in the study of concrete. The material was not expensive and was used in London for housing schemes, being sanctioned by the London County Council, and it was also being used in other parts of England as well as in Scotland and Ireland.

Mr. H. Jackson said that his own view was that in concrete, however made, engineers had a new material from which it should be the aim to get the maximum service, and experience showed that the more uniform the particles contained in the concrete and the more uniform the spaces between the particles, the stronger would be the finished article. That was what Mr. Wentworth-Sheilds was after, and it was also the aim of Professor Abrams' experiments. The ideal material for compression was that in which there was the minimum amount of water to ensure the material working around the bars.

Mr. Wentworth-Sheilds in a brief reply to the discussion, said that whilst everybody seemed impressed with the value of the recent researches of Professor Abrams on the cement-water ratio, they were not quite unanimous as to the value of the slump test. He personally thought the value of the slump test was that it called the attention of the man who turned on the water tap—and he was probably the most important of all—to the importance of not overwatering and at the same time of having too little water. It was quite true that it was dangerous to have too little water, and he regarded the slump test as of value in making everybody aim at getting uniformity in the consistency of the mix. It was the evaporation of the water in the early stages which caused concrete to become porous. Therefore it seemed that in order to obtain permanence in the concrete everything possible should be done to retard evaporation of the water whilst the concrete was being cured. Indeed, he believed it would eventually be found advisable even in cool climates and wet countries like our own to take enormous trouble to cure concrete in under-water conditions, or, if it could not absolutely be put under water, then wet cloths or sand should be placed upon it to keep it wet for the first week or month whilst the concrete was being cured.

For the reading of the next paper the chair was taken by Sir Brodie Henderson.

DEVELOPMENTS IN THE USE OF MATERIALS IN RAILWAY ENGINEERING.

By CHARLES JOHN BROWN, M. Inst. C.E.

Of the forms in which mild steel has been used in bridge work, one of the most objectionable, from the maintenance point of view, is pressed troughing, and the designing engineer who has any consideration for those responsible for the upkeep of his structures will avoid as far as possible its use in bridge floors where difficulties of drainage may arise and in places where it may be exposed to serious corrosion, *e.g.*, where one railway has to be carried over another. Trough flooring used under such conditions has led to many bridges having to be condemned prematurely.

If rustless steel of adequate strength can be made available in the ordinary sections for bridge work at a suitable price it will go far towards solving one of the most troublesome problems that face the maintenance engineer in dealing with steel girder bridges.

In bridge work the elimination of corrosion makes the eventual extension of the use of reinforced concrete, wherever practicable, a certainty; and even where steel in the exposed form cannot be wholly avoided the engineer will strive to substitute, as far as possible, reinforced concrete work.

The suitability of reinforced concrete for strengthening existing metal structures, where the design admits of such treatment, has been well demonstrated by the Paris-Lyons-Mediterranean Railway engineers in dealing with two cast iron viaducts, each of several arched spans, which carry their tracks over the Rhone near Lyons.

For bridges over railways subject to the fumes of locomotives the use of reinforced concrete is advisable wherever it can be adopted, whether done *in situ* or in the precast form, and even over lines carrying heavy traffic its construction *in situ* is becoming quite usual practice. Many footbridges have been built by both methods over running tracks, the relatively light weight of the precast parts making erection of the precast structure a very simple matter.

The introduction of reliable "rapid-hardening" brands of Portland cement is proving of great benefit to railway engineers, especially those responsible for maintenance. With this material it is no longer necessary to allow concrete some weeks to mature before it can be put into service; moulds can be stripped twenty-four hours after the material has been put in place, while piles can be driven safely less than a week after casting.

As a protective coating to steel work fine concrete of proper composition, consistency and thickness to make it waterproof has been used in a number of cases, especially for undersides of metal overbridges which are in close proximity to the blast from locomotives.

As regards track, the rails of "higher carbon" steel—45–55 tons per square inch tensile strength—in lengths of 60ft., supported on heavy cast iron chairs resting on creosoted timber sleepers, are now standard. For places where wear is excessive steels of still higher quality—manganese, chromium and others—have for some years been available and are used when conditions justify the extra cost. The ordinary higher carbon rail steel can also be subjected in course of manufacture to special processes which give the best wearing qualities consistent with reliability in service. These results are usually obtained by cooling the hot steel, immediately after it leaves the rolls, by air or otherwise, under carefully controlled conditions; but the tempering of the steel by quenching after heating to a suitable temperature and subsequent reheating and cooling slowly in air is also done for special purposes.

The pressed steel sleeper, which has been adopted to a very appreciable extent on some railways abroad, is beginning to be considered seriously in this country, but concrete sleepers are still in what may be regarded as the experimental stage, though with the greatly superior quality of the Portland cements now obtainable the prospect of producing a satisfactory concrete sleeper is improving.

Mr. W. W. Grierson expressed the view that reinforced concrete for railway and bridge work will undergo a considerable extension in the future. In looking towards a considerable extension of ferro-concrete construction for railway purposes in the future he felt that it would take place on the question of cost in comparison with steel work or brick and stone work. In that he did not include bridges of the girder type other than for moderate spans, because a great deal more information was wanting as to the behaviour of reinforced concrete for such structures than was at present possessed, especially in relation to fast-running loads. Well-constructed reinforced concrete had very large claims to economy, and it did not necessarily follow that a construction with cheaper first cost would be the cheapest in the end. During the war experiments were carried out with concrete sleepers, but they were not very satisfactory, although it was possible that a suitable concrete might now be forthcoming. The lightest sleeper of that type weighed 150 lb. and the heaviest 300 lb., and that weight, as well as the difficulty of handling, would tell against them. If a pressed steel sleeper with a chair bracket could be made at a cheap price it would compete with timber, because there was also the question of longer life to be taken into account. He would like to hear something about special steel for rails.

Mr. George Ellson suggested that rustless steel was more important for roofs than for bridges owing to the high cost of labour for keeping roofs in repair. Ferro-concrete he regarded as likely to be rather a substitute for timber work for piling, dock fronts and other places, than as a substitute for steel, and he also believed it might come in for sleepers. As regarded pressed steel sleepers, he had had some on the London-Portmouth main line for seven and a-half years and they were in perfect condition still, whilst the ganger said they gave less trouble in maintenance than timber. The sleepers were made complete with chairs, which reduced the initial cost. In two other places the same success had not been obtained, and he did not know whether that was due to the difference in type. Special manganese steel rails had been experimented with on his line, but they had the disadvantages of high cost and low conductivity for electrification purposes. At the same time the life was three or four times that of ordinary rails. The next best results had been obtained with chrome steel rails, which had been in use for four years and a life of three times that of ordinary steel had been obtained on a section of the line subject to heavy side wear owing to electrical working. Some special heat-treated steels had also given good results. The one snag with chrome steel rails was that, if the percentage of chromium was a slight amount too high, there was a tendency to brittleness, and one or two rails had broken.

Mr. Sandberg remarked that although rails in this country had the satisfactory life of twenty-one years on the average, they wore out rapidly on electrified rails, and there seemed to be a need for a superior quality of material. He had always endeavoured to steer clear of that excessive chemical hardness which was introduced in America, as the result of which a large number of failures had taken place. A sorbitic steel, which gave both toughness and hardness was the best. For some years experiments had been carried out by his company with pressed steel sleepers with the idea of embodying the chair in the sleeper itself, because he did not like something in the neighbourhood of sixteen pieces to make up a sleeper, chair and fittings. In that way it was hoped to accommodate a bull-headed rail in place of the flanged rails now so common, a procedure which would have many advantages.

Mr. A. T. Gregson asked whether the elimination of corrosion mentioned in the paper was due to a more careful selection of the aggregate or to the use of rapid hardening cement. He was inclined to think it was due to the latter. What action did the blast from the furnaces of the locomotives have upon reinforced concrete bridges, bearing in mind the need for protecting such structures from the effects of sulphur. On the electrified lines in Milan experiments were being carried out with reinforced concrete poles, 18 m. high and carrying 24,000 volts. They were of spun concrete, which was particularly dense, and it would be interesting to know if anybody else had had experience of that kind. As regards the strengthening of existing bridges with reinforced concrete he believed the cast iron bridges on the

P.L.M. Railway in France had been successfully treated in that way. Eight years ago he had attacked that problem in connection with Telford bridges and the one at Bettws-y-Coed in North Wales was widened from 20ft. to 28ft., others having been widened from 20ft. to 24ft. in order to meet traffic conditions.

Dr. W. Lowe-Brown spoke of the use of high-tensile steel in railway work elsewhere than in this country. At the Sydney Harbour Bridge steel up to 95,000 lb., with a good elongation, was used. He had found the life of manganese rails to be very much more than the three times mentioned. Some manganese crossings which had been put into use in 1924, and over which 50 million tons of traffic had passed, and another, over which 100 million tons of traffic had passed, were still in good condition. Ordinary rails, although 51 to 55 tons, gave out in two years under the same conditions.

Mr. Brown, replying, said that the greatest amount of work upon steel sleepers had been done in Germany, and the experience there was that they lasted fifteen years on main line and could then be used for secondary lines and sidings. That was not very much better than was got with timber, and for the moment he would prefer to stick to wood.

Mr. Roger T. Smith presided over the third and final paper in this section.

RAILWAY DESIGN AND MAINTENANCE AS AFFECTED BY THE APPLICATION OF ELECTRICITY.

By GEORGE ELLSON, M. Inst. C.E., and ARTHUR REGINALD COOPER, M. Inst. C.E.

Electric Traction Equipment.—Different views are held as to whether the most convenient position for the conductor rail is on the 6ft. side or on the cess. It is often claimed for the rail located on the cess side that there are fewer interruptions in the continuity of the contact, and that the 6ft. is the most suitable place for handling and depositing material and tools. The main disadvantage of a rail on the cess side is said to be that men have to step over it when getting clear of the track, but this appears soon to become a habit with them. In certain cases it is the practice to put the conductor rail on the 6ft. side through stations or where it is situated on the high side of checked curves, or again where a siding on which shunting takes place is adjacent to the cess side.

In the earlier installations continuous protection was provided for current rails carrying 600 volts, but protection is now provided for this pressure only at such places as footways across the track, through platforms, where shunting or uncoupling takes place, and where men require to pass or to work in close proximity to the conductor rails. In many cases the ends of the conductor rail at level crossings are protected. Where a large measure of protection is thought to be necessary double boarding is used, a single board on the outer side being sufficient in other cases. These boards are supported either from the rail or direct from the sleeper. It is difficult to say to what extent the protection should enclose a conductor rail at 1500 volts, and it may be that the present form of rail, with the addition of protection boards each side extending a short distance below the rail, will be considered sufficient.

Maintenance Under Electric Traction.—The presence of conductor rails on the track increases the cost of permanent way maintenance. An additional payment of 2s. per week is made to men working on tracks with conductor rails, but this naturally cannot be taken as a measure of the additional cost. There does not appear to be any great change in the number of men employed per mile, but more work is done by special or extra gangs. The short intervals between electric trains on some railways has increased the work carried out at night.

Opinions differ as to whether the permanent way staff should be protected against contact, either direct or indirect, with a live rail, or whether it is better to let them fully realise the danger and keep clear of the live rail.

The lower centre of gravity of electric stock, the smaller diameter of the wheels, and other factors, contribute to increase rail wear.* More side cutting takes place on high rails of curves with electric working, and on some lines a reduction of super-elevation has been found to reduce this side cutting. Improvement has also resulted from a small widening of the gauge. Irregular wave-like wear at the side of the rail has occurred both on the straight and on curves. On the Underground Railways irregular wear on the top of the rail takes place on sharp curves, and if the rail is not unduly worn as regards total depth it is planed and reinstated. Manganese steel is used to a limited extent to meet conditions of abnormal wear, but it is costly and there is a wide field for a rail steel having better wearing qualities than ordinary hard steel, at a reasonable cost. Any steel used for track rails should have satisfactory electrical conductivity; manganese steel is unsuitable in this respect.

It is suggested that the discussion should include the following matters:—

(1) Should the 6ft. or cess be the standard position for the positive conductor rail?

(2) Should insulated tools or tools of an altered design be used by platelayers when working on electrified tracks?

(3) Are the present arrangements for protective planking satisfactory, and should this planking be supported from the current rail direct or by brackets from the sleepers?

(4) Is overhead or conductor rail current collection to be preferred for voltages higher than 650 volts?

(5) To what extent is the cost of maintenance of permanent way increased owing to:

(1) The presence of the equipment making the ordinary work more difficult to carry out?

(2) The different effects of electric rolling stock as compared with steam stock?

(6) To what extent should the maintenance of the electrical equipment be undertaken by permanent way gangs, with special reference to any work of an electrical nature, such as bonding, being included in their duties?

Mr. A. Newlands, speaking on the question whether the positive conductor rail should be in the 6ft. way or in the cess, said that there were instances of both which were working quite satisfactorily. As to the use of insulated tools, he preferred to provide the men with rubber handles and covers for their tools which had to be put on every day, as that made them aware of possible danger and reminded them constantly of it. He attached protective planking to the rails rather than to the sleepers, but he thought it possible that planking might be dispensed with altogether. For voltages higher than 650 he preferred overhead collection, because it minimised the difficulties of track maintenance. The effect of the presence of electrical equipment upon the cost of maintenance was a difficult question to answer, and the reports of his district inspectors were not in agreement upon the point. The increased cost of maintenance of electrified tracks was, in some measure at any rate, due to the greater use of the tracks under electrical conditions; too often it was attributed to the presence of the live rail hampering the work. It had been found, however, that the wear of rails on electrified tracks was heavier than on steam tracks.

Mr. John Wilson, chief electrical engineer to the Buenos Aires Western Railway, said that on that system there was a large amount of trespassing, and an under-running conductor rail had been adopted with a top wooden protection. The third rail was normally in the 6ft. way, but there were lengths of line where it was in the cess. That was done for two reasons. In the first place, it avoided the necessity for the peons having to step over a third rail when moving out of the way of oncoming traffic, and, secondly, because it was found that in doing so the peons usually trailed their spades after them and caught them in the third rail. Manganese steel had been used for special work at terminal stations, but owing to the higher electrical resistance of that section of the track, he had laid down either an additional negative cable jumping across that particular section, or additional rails had been laid in the centre of the track to improve the conductivity.

Mr. John Gresley also expressed the view that for voltages above 650 overhead collection was the best and safer system. He thought it would be useful to make this distinction between the higher and the lower voltages to facilitate inter-running, owing to the difficulty of third-rail collection with 1500-volt locomotives. Although the under-running contact rail was safe enough, there was danger from the workmen's tools catching underneath.

Mr. Edward Wilson thought the conductor rail should be in the cess except through stations, when it should be in the 6ft. way, where it was safer from the point of view of anybody falling off the platform. He preferred not to have insulated tools, but to hand the men out insulating covers, mats and gloves. The best position for the planking was direct on the sleepers. Electrical working seemed to punish the rails more than steam working, and the side cutting was considerably more. There was also more corrugation of the rails.

Mr. Ellson, who replied to the discussion, thought that the choice of overhead or third-rail conductors would rest upon cost. For low voltages the cost of the overhead system would be such as to put it out of consideration. Personally, he could not but think that the presence of third-rail equipment must increase the cost of maintenance, owing to its hampering effect upon the work of the repair men. That was apart from extra traffic; there was also the extra side cutting that had been mentioned. On the Southern Railway insulated tools were used, but if it were found that they were not necessary, the practice would be discontinued. On that railway the divisional engineers maintained the conductor rails, the bonding of the track and the bonding of the conductor rails under the supervision of the electrical engineer. He did not know whether that was altogether the best system, and he was contemplating making a change, as he felt it would be better for the maintenance of the conductor rails and all appurtenances due to electrification to be in the hands of a special staff administered possibly from the head office, working in close conjunction with the civil engineer.

IN THE THEATRE OF THE INSTITUTION.

Sir John Biles presided, when the following paper was presented.

STEEL FOR SHIPBUILDING.

By Sir WILLIAM J. BERRY, K.C.B.

It is obviously a necessary condition that, within the limits of the maximum stresses legislated for, a ship structure should behave as nearly as possible as a perfectly elastic structure, and it has been the aim of ship designers, ever since it became possible to compute with some degree of accuracy the stresses to which ship structures were subjected in service, to keep such stresses within what might be loosely termed the elastic range.

In the case of commercial structural steels as ordinarily produced the proportional range of elasticity is extremely variable, and might almost be said to be an accidental property of the steel; but this feature is subject to control, if for a specific purpose a definite proportional limit is desired. It is only comparatively recently, however, that this has been attempted on a commercial scale by steel makers for constructional steels. This point was investigated with great thoroughness at the time the Admiralty was drawing up the specifications for the steel for some of the recent warships. With the help of some of the foremost steel makers in the country, a steel has been evolved for Admiralty use—now widely known as D quality—in which a proportional limit of 17–20 tons per square inch is associated with an ultimate strength of 37–43 tons, without sacrificing to any appreciable extent the ability of the steel to withstand ordinary manipulative treatment in a shipyard.

To secure such results, great care has to be paid in the first place to chemical composition, and, in the second place, to the choice and control of the finishing temperature at the rolls. As regards chemical composition, advantage is taken of the beneficial effect of increased percentages of manganese, in elevating the proportional range without detracting from ductility. A fairly representative composition would be carbon 0·33, manganese 1·1 to 1·4, silicon 0·12, sulphur and phosphorus being kept to about 0·03 or 0·04 per cent.

The temperature of finishing the rolling is all-important, as it enables a normalising effect to be obtained without actually going through the procedure of a separate treatment. For steel of the composition given, a temperature of 830 deg. to 860 deg. Cent.—or rather above the critical range—is the one to be aimed at. In the early stages of D-steel production, a separate normalising of the material was not uncommon, but steel makers found that with experience this could be wholly dispensed with—except in the case of a further specialised variety of the same steel for which a much more severe bend test is required.

At the present time, after five years' experience in the manufacture and working of this type of steel, it is found that it can be obtained without difficulty from competent steel makers, and can be treated in the shipyard almost with the same facility as mild steel.

In 1925 Lloyd's issued a memorandum on the subject of "Special Quality Steel for Merchant Shipbuilding," sanctioning the use of steels similar in character to that adopted by the Admiralty, but with the ultimate strength kept to a lower figure and the proportional limit lowered to 15 tons per square inch. A reduction of one-tenth in the scantlings is permitted below those specified for ships of mild steel.

Another specification of a similar character followed by Messrs. Alfred Holt and Co. is for a 29–34-ton steel with a limit of proportionality of 15 tons per square inch.

In both these cases the elongation and bend tests are the same as for mild steel. The method of measuring the proportional limit follows in every particular that laid down by the Admiralty for D-quality steel.

The discussion was opened by Mr. Benjamin Talbot, President of the Iron and Steel Institute, who said that British works were quite ready to supply special steels, but greater care in manufacture was needed, with corresponding increased expense. The same yield per ingot could not be got from "D" steel or "Lloyds" steel as from mild steel. The new steels could now be produced as rolled without a secondary normalising process. If normalising were insisted upon a large additional plant would be necessary, and such secondary treatment was, he thought, unfortunate and might prevent the new steels from being employed for ordinary purposes.

Sir Westcott Abel said that in the ordinary Admiralty steel the limit of proportionality was 17 to 20 tons with a small elongation and in the new steels 15 tons with a greater elongation. In general working the qualities of the latter steel did not differ from good mild steel. It was understood that the new materials must not take up any measurable permanent set within the limits of stress specified. A new property had been introduced by the guarantee of limit of proportionality. That, as Sir William Berry had remarked, might be as low as 3 to 4 tons per square inch for a mild steel, but an average was about 8 tons per square inch. To-day with the new steels values of 15 tons per square inch were made possible. Sir Westcott suggested that the new steel might fittingly be termed "dynamic steel," on account of its suitability for live loads. He thought that designers were justified in accepting higher stresses because of the guarantee of no permanent set. Employing two-thirds special steel and one-third mild steel, Alfred Holt and Co. and Sir John Ellerman had reduced their scantlings and had obtained a saving of 10 per cent. in the weight of the ship's structure. The only trouble was the matter of price. An increase of £2 10s. per ton swallowed up any gain obtained. The experience with the new steel, both in the Navy and in merchant ships, had, he thought, been most satisfactory, and he suggested that shipowners and steel makers should now co-operate to bring about its more general introduction and consequent reduction of price.

At this point Sir John Biles read from the chair a written communication from Mr. John Anderson, of Scott's Shipbuilding and Engineering Company, Ltd., Greenock, which stated that on the M.V. "Eurybates," by use of 50 per cent. of special steel, a saving in weight of 10 per cent. had been obtained, which saving might possibly be increased by a further 4 per cent. in future cases.

Mr. T. M. Service, of William Beardmore and Co., Ltd., referred to some points in the manufacturing process, and showed sulphur prints taken from ingots for ordinary mild steel and for special steels. For the latter it was, he said, very necessary to start with a good quality ingot free from blow-holes and segregations. He held that the method of taking the limit of proportionality was important, and there should be no confusion between the yield point and the true elastic limit.

Professor W. Lea, of Sheffield, said that the limit of proportionality or the elastic limit was most important when dealing with compressive stresses, as if deformation took place excentric loading was increased. He was not so sure that a high yield point was equally desirable, for if cold bending had to be done a low yield point had a definite advantage. In the finished structure he thought that material having a lower yield point would permit a partial plastic yielding at joints unequally stressed, which would allow a more uniform distribution of stress in the structure.

Mr. J. Foster King said that the limit of proportionality was a useful test figure, but its determination took time.

Sir Archibald Denny said that he was pleased to hear that little change in method would be necessary for shipbuilders who used the special steels; that was reassuring. He expressed the hope that steel makers would do their best with the increased knowledge now available to produce higher qualities of ordinary mild steel alongside the high elastic limit steels.

Mr. Grimshaw Martin, of Alfred Holt and Co., supported Sir William Berry's statement that an elastic limit as low as 3 tons per square inch for ordinary mild steel could be found. He gave an instance of testing over twenty ships' plates with an average value of that order. He thought that about

8 tons was a safe value for the true elastic limit of mild steel. As the carbon content of a special steel was increased there was a tendency towards its unequal distribution, which led to brittleness and segregation. That did not take place with a heat-treated steel, which had the advantage of equal qualities both in a longitudinal and transverse direction. He thought that uniformity of structure should be striven for, and for that reason a heat-treated steel was preferable to a high-carbon steel with a tendency to brittleness.

Mr. J. A. Jones, of the Research Department at Woolwich, dealt with the question of the effect of manganese in the manufacture of mild steel and special steels. The special steels were cast in iron moulds with a refractory head, and particular care was taken with regard to the temperature in the soaking and finishing processes. The speaker then went on to analyse the effect of adding manganese, on which subject he contributed three articles to THE METALLURGIST in October, November, and December of last year.

Mr. W. Simons, of Guest, Keen and Nettlefolds, Ltd., speaking as a manufacturer, pointed out that the true elastic limit or the limit of proportionality was not a proportion of the yield point and might vary very considerably. The 3 tons and 8 tons mentioned in the note would not be accepted by steel makers without criticism. For ship plates rolled to Lloyds' tests he thought that a limit of proportionality of 13 to 15 tons should be given, and ordinary mild steel should give 12 to 15 tons per square inch. With the special steels there had been an accompanying improvement in methods of testing and greater care in manufacture and treatment.

Professor B. P. Haigh, of Greenwich, said that the outstanding feature of Sir William Berry's note was the reliance placed on the tensile test as being suitable for shipbuilding material, whereas in other branches of engineering the fatigue and notched bar tests had shown such reliance to be optimistic; indeed, the tensile test was held by some to be but a poor guide to the strength of a material. He thought that the fatigue strength of a material was a matter worthy of careful research. The fatigue limit often bore very little relation to the elastic limit. The fatigue strength of a material took some time to determine, but he thought that such a determination was worth while. The relative safety of material under alternating stress depended, not alone on the range of stress, but also on the average value of the stress compared with zero.

In his reply Sir William Berry briefly touched upon points raised in the discussion. The Admiralty, he said, had now dropped normalising entirely, and yet a ductility and limit of elasticity was obtained always better than that specified. The specimen on view showed that there was no brittleness or lack of ductility. The new steels, which were first used for the strength members of the "Nelson" and "Rodney," would be applied to all the new ships, and the stresses worked up from ship to ship. Replying to Professor Haigh, he said he did not think that fatigue came into ship design. Sir William gave the following summary of the qualities of the steels referred to in the note and the discussion:—

Description of steel.	Ultimate strength. Tons/sq. in.	Yield point. Tons/sq. in.	Limit of proportionality. Tons/sq. in.
"D"	37–43	25	20
"HHT"	37–43	22 approx.	—
"Lloyds" (new)	33–38	—	15
"HT"	33–38	20	—
"Holts"	29–34	—	15
Mild steel, old Liverpool register	28–32	—	Average about 8
Mild steel, old Admiralty	26–30	—	
Mild steel, old Lloyds	28–32	—	

Engineer Vice-Admiral Sir Robert Dixon presided at the joint discussion of the two following papers:—

THE GENERATION AND UTILISATION OF HIGH-PRESSURE SUPERHEATED STEAM FOR MARINE PROPULSION.

By Lord WEIR and HAROLD EDGAR YARROW, Assoc. M. Inst. C.E.

The economic situation calling for reduction in costs of marine transport applies with special significance to British shipowners owing to existing high wages costs, dock and handling charges, and taxation. Equally important is the necessity for maintaining the utilisation in some way of British coal instead of imported liquid fuel. If methods of continuous external combustion of fuel are to be employed instead of intermittent internal combustion, and if fuel costs are to be reduced, recourse must be had to the use of higher temperatures and pressures of the working fluid than those hitherto adopted. It is not difficult to estimate the possibilities presented of increased thermal efficiency with higher pressure and temperature. From the thermodynamic aspect there is no maximum limit to the temperature which might be used, but there is a practical limit fixed by the nature of the materials available. The corrosive and erosive effects of the working fluid are intensified by high temperature, but the definite limitations are imposed in the main by the weakening influence of temperature on the constructional materials commonly in use. Beyond temperatures of, say, 750 deg. to 800 deg. Fah. slight increases in temperature will produce great diminution in strength.

An examination of pressure effects involves a consideration of the properties of steam and the thermodynamics of the various steam cycles. If the purely theoretical cycles are considered, so far as increased thermal efficiency is concerned, there is no limit to the pressure that might be used. But this only presents the initial aspect of the problem and in order to form a reasonable judgment some idea of the influence of pressure upon turbine efficiencies must be obtained. Briefly stated, increased pressure involves increased expansion in the high-pressure field as well as in that of saturated steam. To meet the wetness difficulty maximum initial superheat or reheating is necessary. The effect of high pressure upon stage efficiencies can only be determined by a detailed examination of pressure effects upon nozzle and blading losses, disc friction, and leakage losses. In addition to such examination the influence of stage feed heating and reheating should also be included, since it is clear that the full thermodynamic gain due to the use of high pressure and temperature can only be realised by taking advantage of such variations from the usual Rankine cycle.

The results of such an examination show that, by taking advantage of stage feed heating and reheating the possible efficiency increases fairly steadily up to a pressure of about 1000 lb. per square inch. Higher pressures promise some slight advantage of thermodynamic gain, but probably too little to justify much advance beyond that limit. It has been estimated that, taking as the "limiting cycle" initial conditions of 1250 lb. per square inch and 900 deg. Fah. with two reheating and eight feed heating stages, a consumption of about 0·37 lb. of oil or 0·67 lb. of coal per horse-power hour might be expected. In marine plants such an elaborate cycle could not be employed, but Sir Charles Parsons, M. Inst. C.E., has calculated* that a turbine of 5000 S.H.P. using steam at 500 lb. per square inch and 700 deg. Fah. with extraction feed heating but no reheating, might be expected to use about 0·57 lb. of oil—or 0·87 lb. of coal—per horse-power hour.

The problem of obtaining such degrees of fuel economy in marine practice are associated more with the generation of steam than with its utilisation. For the pressures now contemplated the boilers must be of the water-tube type, and experience on shore, and to a certain extent at sea, has shown that this type of boiler is eminently satisfactory from the standpoints of both reliability and maintenance, provided the feed supply is pure. By the use of hermetically sealed surface condensers having tubes of high nickel content, and a closed or de-aerated feed system with low-pressure feed make-up apparatus forming a definite part of the heat balance scheme, no practical difficulties are now presented.

It is clear that such boilers must work under conditions of combustion efficiency higher than can be achieved continuously with hand firing, and this points to the use of fuel oil, mechanical stokers, or pulverised fuel. Similarly it involves taking as much as possible of the heat of the fuel at the highest possible thermal datum to the working fluid. With such high steam temperatures it is clear that regenerative processes must be employed to prevent serious losses in the final flue gas temperatures. Of these the most obvious is preheating of the air, a process highly beneficial to combustion and now commonly in use. If generation in two stages is accepted, some advantages would accrue from having a single furnace with a radiant heat water-tube boiler working at the higher pressure, the gases then passing to a normal convection type of multitubular marine boiler working at a normal pressure and supplying steam to the turbine at a later stage. Another alternative would be to have a single-furnace high-pressure water-tube boiler, both radiant and convective, and a multitubular boiler working at, say, atmospheric pressure.

The case for the adoption of the water-tube boiler in the marine field is now very strong. The manufacture of high-pressure boilers, although needing care as regards both design and construction, presents no insuperable difficulty.

There appears to be little real difficulty with high-pressure steam in the turbine itself. Such difficulties as have occurred have been attributable to impurities in the steam, and when these are removed and proper provision is made in the design for expansion due to the wider temperature range, it seems proved that upkeep costs will not be excessive.

Is it then possible to conserve in one installation the best features of modern practice in fuel handling and preparation, combustion, heat cycle lay-out, and boiler and turbine design, and to apply such an installation with appropriate modifications to meet marine conditions? If this can be done, the result will be a propelling unit of minimum fuel cost, and lower weight, bulk, and intrinsic first cost than any form of propelling machinery of equal thermal efficiency. A successful solution would open a new era in marine propulsion and would substantially assist the British coal situation. With such a premium on success it is not to be doubted that the work already begun in this field will be prosecuted with increased activity.

PROGRESS IN THE ADOPTION OF THE INTERNAL COMBUSTION ENGINE FOR MARINE PURPOSES.

By Professor CHARLES JOHN HAWKES, Assoc. M. Inst. C.E.

Whilst the early difficulties with the marine oil engine have been largely overcome, the increase in the dimensions of cylinders has introduced further difficulties. The maximum continuous power that can safely be developed by an engine depends upon the heat flow through, and the thicknesses of, the parts in contact with the working fluid. The volumetric efficiency of the engine and the quantity of fuel burned per stroke are, therefore, of the utmost importance. One of the advantages of the four-stroke engine is its high volumetric efficiency; for the two-stroke engine is generally less favourable in this respect. On the other hand, the four-stroke engine has generally a somewhat complicated cover, while the cover of a two-stroke engine can be a simple casting and can be effectively cooled. With an increase in the dimensions of cylinders there has been a tendency to work with lower mean pressures, that is, to burn a smaller quantity of fuel per unit volume of cylinder. This has been done with the object of reducing cycle temperatures. The dimensions of any type of engine, however, for a given power and speed, are dependent upon the mean indicated pressure employed, and from this point of view a reduction in the mean pressure is undesirable, although perhaps necessary. The alternative is to increase the charge weight of the working fluid within the cylinder by supercharging, and thus enable a higher mean pressure to be employed without increasing cycle temperatures and therefore without increasing the temperature stresses in the material of the parts in contact with the working fluid. The Büchi system of supercharging has been applied to several four-stroke engines with satisfactory results, and this system has the distinct advantage that the blowers required for supplying the induction and supercharging air are driven by exhaust gas turbines.

Much has been said in the past concerning the best cycle of operation. For moderate powers the single-acting four-stroke engine has much to recommend it; but for higher powers, where the single-acting engine no longer meets requirements, the author prefers to look upon the single-acting two-stroke engine as the next step in development rather than the double-acting four-stroke engine. For still higher powers the double-acting two-stroke engine is the logical line of development; but it is a more complicated engine than the single-acting engine, although for large powers it has the undoubted advantage that the number of cylinders can be reduced, and it may be expected eventually to prove a cheaper engine to construct. More attention is now being given to the balancing of engines and to the scantlings of the shafts so as to ensure that any criticial speeds may not coincide with the service speeds of the vessel.

The increase in the sizes of cylinders seems, in some instances, to have had the effect of increasing the rate of wear of liners, and this is causing some concern. The brand of fuel oil or lubricating oil may in some instances have had some effect on liner wear, but in other cases it may be that the material used may not have been entirely suitable. This and other problems arising from the employment of large cylinders call for extreme care in design and point to the need of continued research. The large oil engine must be reliable and readily accessible, but it is difficult to avoid the handling of fairly heavy parts when dismantling for cleaning and examination. The oil engine is more sensitive than the steam engine, and it calls for greater vigilance and care on the part of the engine-room staff; and, although little published information is available, its maintenance costs cannot be assumed to be less than for a steam engine of corresponding power. The first cost of the oil engine is higher than that for steam, and the possible future cost of fuel oil is another point influencing the position. Large cylinders are more difficult to deal with than small cylinders, and consequently step-by-step development is essential. Having this in view, the author often wonders whether progress has not been too rapid. It is true that large powers can be developed by employing a large number of small cylinders, coupled either electrically, mechanically or hydraulically to the propeller shafts; but such an installation would not be without its difficulties and it is doubtful whether there would be any reduction in first cost.

The author does not think that any appreciable increase in the efficiency of the oil engine can be expected without further complication, and simplicity and a reduction in first cost are needed at the present time. At present the oil engine, whilst playing an important part in marine propulsion, is not necessarily the cheapest or the best form of prime mover for all ships and for all conditions of service.

* "The Steam Turbine," International Mathematical Congress, Toronto, 1924.

Mr. Harold E. Yarrow, before opening the discussion, referred to the unavoidable absence of Lord Weir, and showed two models of a 30,000 S.H.P. boiler installation designed on Mr. Johnson's system of combined water-tube and Scotch boilers.

Mr. J. Hamilton Gibson then read a communication from Mr. J. Johnson. After outlining the reasons which led him to adopt stepped boilers with a definite segregation of the main feed from the doubtful condensate of the auxiliaries, Mr. Johnson referred to the successful operation of the C.P.R. cargo steamers during the last six months, which seemed to point to a final solution of the boiler problem. The introduction of high temperatures and high-pressure turbine machinery with combined water-tube and Scotch boilers would reduce the total operating costs of passenger liners by 20 to 30 per cent., and that of cargo ships by 15 to 20 per cent. In the "Empress of Australia," with 220 lb. pressure and 600 deg. total steam temperature, a consumption of 0·69 lb. per S.H.P. hour for propulsion or 0·74 for all purposes had been obtained. For the "Duchess of Bedford," with 350 lb. and 680 deg., those figures were 0·60 lb. and 0·64 lb. per S.H.P. hour respectively, showing a saving of 13 per cent. If the "Duchess of Bedford" had been equipped with machinery similar to that of the "Empress of Australia," the installation would have cost £20,000 more. Comparing a C.P.R. double-reduction turbine-driven ship of 1922 with the "Duchess of Bedford" to-day, the powers were 12,000 and 18,000 S.H.P., with machinery weights of 2400 and 2200 tons. In six years improvements had given a 50 per cent. increase in power with a 10 per cent. reduction in weight. It was possible to employ three 21-knot ships to do the work of four 19-knot ships.

Mr. S. S. Cook corrected a figure, quoted by Sir Charles Parsons and given in the first paper, of 0·57 lb. of oil per horse-power hour, which he said was for turbines alone. Referring to his own British Association paper of 1925, he said that he had calculated the following overall consumptions with different types of auxiliary machinery. Steam-driven auxiliaries, 0·655 lb. per S.H.P. hour; electric auxiliaries and turbo-generators, 0·648 lb.; and electric auxiliaries with oil electric generators, 0·62 lb. Mr. Johnson's figures closely approached those. One difficulty in the way of high-pressure development was the increased work in driving the feed pump as pressures were raised. With regard to regenerative processes for recovery of the heat in the flue gases, air heating was the most efficient process.

Sir Dugald Clerk said that the papers interested him because they dealt with the comparison of steam and internal combustion engines. He was glad to know that steam was coming out so well. Efficiencies of close upon 40 per cent. were now obtainable in the internal combustion engine.

Mr. A. Spyer said that the increased use of coal was a national matter. With regard to high steam pressures, Mr. Spyer said that land in stallations with 800 lb. pressure and 840 deg. Fah. total steam temperature had been in operation on the Continent for three or four years, and there had been no trouble so far. The boiler had been designed taking fully into account the elastic limit of the steel at the working temperature. He did not expect much help from either chrome, nickel or tungsten steels, as they might present difficulties in handling, but in Germany a high carbon and manganese steel was being developed which would be suitable for pressures up to 900 lb. Experience showed that 800 lb. was about the limit for ordinary steels. For the higher pressures solid drawn drums had been advocated, but riveted drums were in use on 800 lb. land boilers, and such drums could certainly be made for a pressure up to 650 lb. Hand firing of coal was out of date, and mechanical stokers were available. Such equipment, however, did limit the descriptions and range of fuels which might be employed. Stage boilers were highly satisfactory.

Mr. Andrew Hamilton stated the case for the smaller ship, in which he said the measure of the machinery installation was the ability of the third engineer to run it; stage boilers and care with condensers should be applied to those ships, but capital expenditure must yield adequate returns. The question of route affected the rival merits of coal and oil.

Mr. Sterry B. Freeman dealt with the question of bunker weight, which was not raised in the papers. In a voyage to Australia 2400 tons of coal would be needed, with a call at the Cape for bunkers. A motor vessel carrying 640 tons of oil in the double bottom

would make the voyage direct. A standard oil engine which could be built at a competitive price was badly needed. Reference had been made to improved steels, but he thought that pearlitic cast iron marked an equally important advance.

Mr. W. A. Tookey made a plea for the younger engineers on motor vessels. They did not, he said, at present actually take charge of the engines during the manœuvring periods. He considered that such experience was essential.

Engineer-Captain W. Onyon said that a year ago he had been held up to ridicule for suggesting that a turbine-driven ship might be more reliable than a large motor vessel. An Italian-owned turbine-driven liner had recently made eight consecutive voyages to South America, whereas two motor liners on the same route had after two round voyages been laid off for repairs. He was impressed by what the Germans were doing with the new Atlantic liners at Hamburg and Bremen, and the importance which continental shipowners and shipbuilders attached to tank experiments.

Admiral Whayman referred to the successful use of coal-fired marine boilers in the recently constructed C.P.R. cargo steamers. Oil might continue to be used for the larger and faster ships, but every effort should be made, he considered, to use coal, probably in pulverised form, in the smaller ships.

Mr. J. H. Narbeth advocated the adoption of a standard design of marine oil engines in each fleet. He thought that with modern oil engines an ultimate figure of 0·30 lb. of oil per S.H.P. should be obtained, which would compare with 0·60 lb. for oil-fired boilers with geared turbines, and 0·9 lb. for coal-fired boilers. More average figures would be 0·40 lb., 0·8 lb., and 1·2 lb., which would apply to the smaller vessels.

Mr. Yarrow and Professor Hawkes made brief replies.

IN THE LIBRARY OF THE INSTITUTION.

Sir Richard Threlfall presided, when the following paper was presented.

UTILISATION OF SOLID AND LIQUID FUELS.

By CECIL HOWARD LANDER, D.Sc., M. Inst. C.E.

It is frequently stated that it is uneconomical to burn fuel in its raw state; but this is at the best only a half-truth, and since any pre-treatment cannot possibly have a 100 per cent. efficiency, it would involve heat losses in addition to those within the boiler furnace. Sir George Beilby, in the James Forrest Lecture of 1921, pointed out, for instance, that the efficiency of a low-temperature carbonisation process amounted to about 80 per cent., and that the deficit would have to be made good by utilising the products of the carbonisation within the final burning appliance, be it boiler furnace or internal combustion engine, with higher commercial efficiency. Gas is the fuel of greatest availability, and the fuel which, generally speaking, can be utilised with the highest efficiency. Going down the scale, the light motor spirit and the heavier fuel oils are also fuels of high availability, since they can be turned into gas by methods which are scientifically much simpler than those employed in the case of solid fuels. An important object of the pulverisation of solid fuel is to render it more analogous to gas, so that the oxygen necessary for combustion can be brought more rapidly into contact with the molecules of the combustible material.

The most important source of fuel in this country, and even in the world, is coal. In its passage from the solid stage to the flue gas stage the whole range of products from solid carbon to liquid molecules and gaseous molecules are involved. Modern boiler furnaces can probably extract and make definite use of a greater proportion of the initial energy of the coal than can any series of processes involving pre-treatment before final combustion. The justification for such pre-treatment thus requires the possibility of monetary savings in other directions. It is impossible to generalise in such circumstances, for the extent to which pre-treatment can be economically applied depends very largely upon local conditions.

Professor Henry Louis (President, Institution of Mining Engineers), discussing the question of solid fuel, referred to the common error of regarding coal as one substance, whereas as it was nothing of the kind; it was not an entity, in the sense that other fuels, such as methane, benzene, &c., were entities, and until the various constituents of the coal were utilised in the correct way, no sound advance in the application of that coal would be made. Coal consisted of, at any rate, three different substances—bright coal, dull coal, and soft coal. The soft coal—fusain—could be separated from the other constituents readily, and was being separated in practically every coal cleaning plant. The fusain, which was the non-coking and high-ash constituent, must be kept out of the coal if the coal were to be used for any distillation process. He was inclined to think that the probable future of fusain was in dust firing. There was not yet any technical working process by which the bright coal could be separated even partially from the dull coal, but he would be a very bold man who would venture to prophesy that such a process was an impossibility, even in the near future.

Mr. John H. Narbeth urged that more substantial steps should be taken to test the Bergius hydrogenation process. Dr. Lander had stated that modern boiler furnaces could probably extract and make definite use of a greater proportion of the initial energy of the coal than could any series of processes involving pre-treatment before final combustion. That was quite true, but we did not want to go to boiler furnaces to get the energy from coal. Roughly speaking, Diesel engines were now running which would give 1 H.P. for 0·4 lb. of oil. The best that could be hoped to be achieved through a boiler was 1 H.P. for 0·6 lb. of oil, or 1 H.P. for 0·9 lb. of coal, but it was rarely that that was achieved. The best at present was 1 H.P. for 0·4 lb. of oil in a Diesel engine; 1 H.P. for 0·8 lb. of oil through a boiler; and 1 H.P. for 1·2 lb. of coal through a boiler. With regard to pulverised fuel, he did not think it could be carried on board ship very well, for three reasons. In the first place, its volume was too great; secondly, in the case of an accident pulverised fuel would block up the pumping and drainage arrangements and prevent the ship clearing herself; and thirdly, there was the fire risk.

Dr. Cullen said that the authors of the very numerous processes existing for the pre-treatment of coal sometimes forgot the possibility of monetary savings in other directions. He considered, however, taking a broader view of the situation, that things had very much advanced in the monetary sense since the last Budget was introduced. Dr. Lander had stated that it was impossible to generalise, for the extent to which pre-treatment could be economically applied depended very largely upon local conditions. The Budget did give some of these processes, at any rate, a distinctly better chance than they had had before, and the success or failure of many of them would depend on taking advantage of local conditions. He looked upon the voyage of the "Mercer," which was mentioned in the paper, as being a great factor in connection with the future utilisation of coal. The danger arising from the storage of pulverised fuel on board ship was a very real danger, but the voyage of the "Mercer" had shown clearly that it was not necessary to store pulverised fuel on board ship, for it could be taken on board in the form in which it was ordinarily marketed, and pulverised on board. One could visualise other great dangers, however. Unless the ash were a highly fusible ash, one could appreciate that there might be very great danger to the boilers in the case of a ship at sea. He understood that the United States Shipping Board had chosen for the "Mercer" a coal whose ash fused at a very high temperature, and it was quite safe for all practical purposes.

Mr. Thomas Clarkson said it appeared that at the present time pulverised coal was not being burned more rapidly than 1 lb. or 1½ lb. per cubic foot of furnace volume. That seemed to be very low, bearing in mind that frequently oil was burned at the rate of 10 lb. per cubic foot of furnace volume, and tests had been conducted in which over 20 lb. per cubic foot was burned quite successfully. The necessity for using large combustion chambers for burning pulverised fuel introduced difficulties with regard to walls. The refractories would not stand up to the conditions, and it was necessary for water-cooled walls, which was not the right solution. He did not think the conditions were ideal when the flame saw so much blank wall; the conditions for ideal combustion could only be obtained when the flame saw no blank wall, and it should be surrounded by an incandescent envelope.

Mr. Dron suggested that investigations should be made to ascertain the value of the fusain constituent of coal. Its extraction from the rest of the coal could be effected by the froth flotation process, but the difficulty of extraction by that process was that the fusain absorbed so much moisture that it was almost impossible to utilise it afterwards. The very fine dust extracted by the pneumatic processes which were now coming into being for the cleaning of coal, however, was composed almost entirely of fusain, and it seemed to him that Dr. Lander and his colleagues, and others, might consider what could be done with that material, which, although to some extent deleterious, he believed could be made one of the most valuable constituents of coal.

Engineer-Admiral Scott Hill said he believed it had been proved now that a much larger quantity of pulverised coal per cubic foot of furnace volume could be burned than was formerly the case. The figure claimed in the case of the "Mercer" was 2·5 lb., but he believed the A.E.G., which was running locomotives on a different principle, claimed 6·5 lb. per cubic foot, which was getting near to the very best that could be done with oil burning. Great progress was being made, therefore, in the reduction of the size of combustion chambers, and it was hoped to reduce the size of combustion chambers in future land installations.

Mr. Toltz said that in North and South Dakota and in Montana, and in Saskatchewan and Alberta, vast quantities of lignite lay idle, and no one knew what to do with it. Two processes of low-temperature distillation had been tried, but without commecrial success. In order to briquette it, a binder would be needed, which could be obtained partly from the lignite. He had been in Europe for the last three or four months, trying to obtain information with regard to it. The only process he had found which appeared to be favourable was a secret process, involving the drying of the lignite to reduce the moisture content to 15 per cent., pulverising it, and then putting it through a low-temperature distillation process, to obtain half coke, and to briquette the coke without a binder. That had been done in the laboratory, but not commercially yet.

Dr. Lander, replying to the discussion, agreed most heartily with Professor Louis in emphasising that coal was not one substance. That fact was brought out every minute of every day in connection with the coal survey of the Fuel Research Board. In that survey it had been found essential to take literally hundreds and thousands of samples—not mere scratchings from the coal face, such as were obtained by picking a groove down the coal face and collecting the material which fell to the floor; it had been found essential to take out a portion of the seam so that the laboratory worker had in front of him a 1ft. square section of the seam from roof to floor as it lay in the mine. That was the material on which the laboratory worker started his scientific work, analysing step by step and applying as many of the known methods of analysis or assay as were suitable to that particular sample. He had endeavoured to bring out in his paper the point which was emphasised by Mr. Narbeth, namely, that there was, and could be, no superlative method of treating coal; there were many widely different methods, and each might be suited to particular sets of local conditions. With regard to the Bergius process, he said there was really a lot going on in this country about which little was known. It was the fact that it was being worked upon intensively at Billingham. The Fuel Research station was not equipped to carry processes through to the commercial stage, neither could a Government Department do anything like that, but it did claim to have had the first hydrogenation plant in this country, imported, of course, from the Continent, and to have made oil in that plant. At the present time, however, it was working on the problem from a more fundamental point of view, and was trying to find out what was the action of the hydrogen on the coal. All he could say at the moment was that that action was very profound. When he stated that by mildly hydrogenating anthracite one could make it into a metallurgical coke, it would give some idea of the effects that could be produced by the hydrogenation of coal. The Fuel Research Board had had low-temperature carbonisation thrust upon it, to its great regret. In spite of the publicity given to it, it did not account for 25 per cent. of the Board's expenditure to date. High-temperature carbonisation, on the other hand, accounted for more than 50 per cent.

(To be continued.)

Advice to Boys.

MR. FREDERICK E. JOHNSON, Executive Officer of the Willesden Urban District Council, addresses the following admirable advice to boys in his little quarterly, called "The Right Start":—

If you want to rise to a position worth having, see to it that the creeping paralysis of present-day conditions does not get into your system. Take this to heart:

> It is going to pay you to work, to work hard, to work intelligently, to work loyally, to work for a goal. Have the grit to carve out your own destiny.

Get right down to the rock bottom of things. What are you going to be? Of course, you have to make up your mind what trade or calling to follow, but this is a different choice. Are you going to be a human sheep, running after any other sheep which happens to be in front of you? Or will you put your back into it, have a definite personality, build up character and will power, and fight for a place? Which will you be—a drifting drudge of industry or a sane, self-reliant and progressive citizen? Never mind what others say to you. By your own choice you will stand or fall in the "War of Brains." No pity will be wasted on you if you become an industrial cripple. The ambulance just wheels you to the scrap heap, and dumps you there.

We want you to have a sporting chance. The system is against you. The whole tendency of our modern life is to sap and undermine the very things which make a sporting chance possible. However much we may try to help you, the first essential is your own personal energy. If you look upon work as a drudgery or as a disgrace, and fail to put every ounce of effort into the battle of life, you cannot hope for anything really worth while.

We have been through a stage when slackness and sloppiness have kept thoroughness and efficiency in the background. We are entering a new era, when the position will be reversed. Thoroughness will come into its own. The competent will replace the incompetent.

If you are following the common-sense lead when the general awakening takes place, you may secure a sporting chance. If you are drifting with the crowd, opportunity will pass you by.

There is no easy road to success, no move upward without strenuous effort, and no escape from what you look upon as drudgery except by your own hard work.

Never mind about the "blind alley" job. Watch to see that you do not become one of the "blind alley" boys.

These are days of combines, limited companies, the elimination of the old personal relations between master and man, mass production, cut rates, and a general atmosphere of unrest and suspicion. But for all boys to look upon all employers as tyrants and Shylocks is not only wrong, but industrially suicidal. There are indications of closer relations and a better spirit of co-operation between masters and workmen.

So far as you, the individual boy, are concerned, the road to take is clearly set out for you. Start with the assumption that, if you do your part, there is a reasonable prospect of those above you doing theirs. Should there be any attempt to exploit your services, you are in a position to seek a different type of management if you have followed my advice, and, by increased knowledge, have something concrete to offer the new employer. Up with your market value. Then you need not be afraid to show the spirit of adventure and move on freely in your own line of work. If, however, you are content to be nothing but a mechanical automaton, dancing to the tune of anyone clever enough to pull the strings, no amount of personal influence can release you from your industrial slavery. Don't let yourself be a marionette. Be a man.

Railway Matters.

THAT part of the Hammersmith and City Railway—jointly owned by the Great Western and Metropolitan Railways—which lies between Bishops-road and Westbourne Park, is to be equipped with automatic signals. Day colour light signals are to be provided.

WRITING to *The Times* recently, Mr. R. A. H. Weight, of Alexandra Park, gave the times of passing during the first fortnight in May of the London and North-Eastern up West Riding Pullman, up "Flying Scotsman," and up "Queen of Scots" Pullman. On every day each of these trains was either early or on right time. Mr. Weight says that the records are entirely the result of authentic continuous observation, which is carried out as a hobby.

THE eighty or so miles of the Great Western between Plymouth and Penzance which, thirty years ago, were all single track, have now gradually been converted to double line. There were three exceptions, one of which is the length containing the Royal Albert Bridge. The other two lie between St. Erth and Marazion, and between Scorrier and Redruth. For some time now the formation for a double line between the first two stations of the latter exceptions has been in hand, and it is now announced that the additional rails and connections have been sanctioned.

A QUESTION was addressed to the Minister of Transport the other day as to the number of persons killed on the Southern Railway as a result of coming into contact with the live rail on these lines equipped for electric traction, and whether the live rail could not be boxed in as on the London and North-Eastern Railway. Colonel Wilfred Ashley, replying, said that since electric traction was introduced in 1905 nine fatal accidents had been caused by contact with the live rail, of which seven happened to trespassers. He added that he understood that protection was provided at places where there was likely to be risk to the company's servants, of passengers or other persons legitimately on the line.

THE coroner's jury, which has inquired into the deaths of the four men who lost their lives in the collapse, on May 11th, of Cofton Tunnel, referred to in this column of our issue of May 18th, returned a verdict of "Accidental death" when the inquest was resumed on June 1st. A rider was added that the jury considered that all concerned did what was requisite and proper in the circumstances. Evidence was given that after the accident it was found that the inner lining below the springing point was stripped on the west side of the tunnel—which was built between 1838 and 1841, and was being taken down. The wall there was only 4½in. thick, and it was thought that the stripping was due to defective brickwork underneath.

Two changes have just been made in the department of the chief mechanical engineer of the London, Midland and Scottish Railway, which are of interest if for no other reason than that the men concerned bear names well known in the locomotive world. Mr. H. G. Ivatt, who went to the North Staffordshire as assistant locomotive superintendent when demobilised and, on grouping, joined the London Midland and Scottish, has been made works manager at Derby in succession to Mr. S. J. Symes, appointed personal assistant to the chief mechanical engineer. Mr. S. H. Whitelegg, who has been in charge of locomotive matters on the North London and Tilbury sections has been removed to Horwich as works manager, in succession to Mr. David Gibson, appointed to be superintendent marine engineer with office at Euston.

The Board of Trade returns for the month of March last show that the value of the railway material exported during the first three months of the present year was as follows, the corresponding figures for 1927 and 1926 being added in brackets:—Locomotives, £700,187 (£274,309, £1,193,197); rails, £1,078,343 (£359,187, £586,327); carriages, £865,688 (£619,074, £556,696); wagons, £1,052,589 (£528,323, £984,975); wheels and axles, £259,551 (£103,651, £138,933); tires and axles, £170,218 (£92,348, £81,640), chairs and metal sleepers, £271,009 (£125,179, £268,050); miscellaneous permanent way, £335,267 (£331,190, £301,588); total permanent way, £2,149,817 (£1,083,727, £1,444,375). The weight of the rails exported was 125,593 tons (40,787 tons, 74,072 tons); and of the chairs and metal sleepers, 27,212 tons (13,384 tons, 27,107 tons). During the month of March, 1928, the value of the locomotives sent overseas was £290,328, and included therein were:—India, £55,798; other countries in South America than the Argentine, £51,612; the Argentine, £27,100; Ceylon, £5959. The corresponding value of the rails shipped was £393,638, and included:—The Argentine, £146,751; British West Africa, £53,396; India, £49,099; New Zealand, £28,105; Chili, £14,577; South Africa, £11,956; Ceylon, £11,868; Portuguese East Africa, £5139.

THE last annual report of the Indian Railway Board observed that some time ago the Railway Board impressed on all broad gauge railway administrations the importance of increasing the number of goods wagons equipped with the vacuum brake, with a view to running all goods trains with vacuum brake throughout from engine to brake van. The matter had also been taken up by the Indian Railway Conference Association, and a system of penalties was devised in regard to the interchange of wagons not properly equipped. Among the advantages gained, beyond the greater safety, higher speed and the ability of the guard to apply the brake in case of emergency, were the reduction in brake van tonnage on the Ghat sections, with corresponding increase of paying freight; the longer life of the rubber fittings of the brake, as the brake is in continuous use and the fittings do not deteriorate through disuse, and the localisation and prevention of theft of vacuum fittings. The report proceeded to say that the efforts of the Board and of the administrations had resulted in the majority of the broad gauge goods trains being equipped with the brake throughout. The percentage of goods trains run with the vacuum complete was as follows—in March, 1927:—Madras and Southern Mahratta, 99·5; South Indian, 99·4; Great Indian Peninsula, 99·2; Bombay, Baroda, and Central India, 99·1; North-Western, 97·7; Bengal-Nagpur, 85·2; Eastern Bengal, 81·8; East Indian, 69·0.

Notes and Memoranda.

THE number of automobiles manufactured in Canada in March reached 17,478, valued at about £2,542,000, an increase of 39 per cent. in number and 51 per cent. in value over the February output of 12,504, valued at £1,688,400. In March, 1927, production totalled 23,250 cars, valued at nearly £3,070,000. Compared with the previous month, March production showed an increase in all types of cars with the exception of open passenger cars, which dropped to 1,445 from 1788. Closed model passenger cars advanced to 12,805 from 8292; trucks to 257 from 211; chassis to 2967 from 2213; and four omnibuses were produced.

ACCORDING to the report of the Shanghai Electricity Department for the year 1927, the overall efficiency of the Riverside power station was 17·41 per cent., as compared with 17·89 per cent. for the previous year. The B.Th.U. per kilowatt-hour generated were 19,701, compared with 19,108 in the previous year. The decrease in overall efficiency is in the main due to the adverse conditions prevailing for a considerable proportion of the year under review, when the demand was much below normal and efficiency of operation necessarily suffered. The maintenance of efficiency at the figure actually achieved constitutes a tribute to the ability of the staff concerned.

A FURNACE which has recently been designed to replace the old-fashioned muffle furnace for the incineration of samples for chemical analysis is referred to in *Nature*. In this furnace the bulky fire-clay parts have been very greatly reduced in extent and replaced by tall, thin cylindrical shells, in which the air can circulate freely under its own draught round the specimen. Four of these shells are mounted on one base and the simultaneous combustion of four samples can be completed in less than an hour without the addition of oxygen or of solid oxidising reagents; nor does the sample require attention during the combustion. The furnace is supplied by Messrs. Armin Kühn, of Charlottenburg.

THE production of pig iron in the United States during the year 1927, exclusive of ferro-alloys, was 35,875,129 gross tons, compared with 38,755,698 tons in 1926. Thus, the production in 1927 was about 7 per cent. less than in 1926, but it was about 4 per cent. more than the average for the preceding five years. In the production of pig iron in 1927 there were used 61,718,383 gross tons of domestic iron ore and manganiferous iron ore; 2,540,558 tons of foreign iron ore and manganiferous iron ore; and 5,602,006 tons of cinder, scale, and scrap; a total of 69,860,947 tons. An average of 1·947 gross tons of metalliferous materials was consumed per ton of pig iron made in 1927, as compared with 1·925 in 1926.

THE value of new aluminium produced in the United States during 1927 was over £7,850,000, an increase of 4 per cent. as compared with 1926, according to a statement prepared by J. M. Hill, of the United States Bureau of Mines, Department of Commerce. The principal producing plant was that at Massena, New York, where approximately half of the metal made in the United States was recovered. Other works are at Niagara Falls, New York; Alcoa, Tennessee; and Badin, North Carolina. The control dams on the Yadkin and Little Tennessee Rivers in North Carolina were completed, thus assuring continuous power for the Badin and Alcoa plants of the Aluminium Company of America, which heretofore have been short of power at times of drought.

SOME indication of the magnitude of the operations of the British Columbia Electric Railway Company may be gathered from the fact that its services embrace an area of 1500 square miles, in which there is a population of over 375,000. In addition to the 212,200 horse-power already developed by the company, the new Bridge River project now under construction has an ultimate capacity of 700,000 horse-power. Two units of 30,000 horse-power each will be in operation in 1930. The present equipment consists of five large hydro-electric plants and two large steam plants. Two additional "hydro" plants are now in the course of construction. Power distribution involves 420 miles of high-tension transmission lines and 1654 miles of distribution wires. The company has 94,611 light and power customers, and has had an output from its seven plants of 403,986,536 kilowatt-hours.

BY using a special cement the Chicago Burlington and Quincy Railway Company is reported to have placed a siding track in service within nineteen hours after the concrete slab was completed. The track alongside a warehouse had settled and was badly out of line. Water was draining into the warehouse basement, and it was decided to pave the track with concrete. The track was raised to the proper level, the ties resting on two 56 lb. rails and granite blocks. A concrete slab approximately 135ft. long, 14ft. wide at the surface and 9ft. wide at the base, with an average thickness of 2ft. was then constructed. The concrete consisted of 1 part Quikard cement to 3½ parts sand-gravel and 5½ gallons mixing water per bag of cement. The concreting was started on a Saturday afternoon and completed on Sunday evening. Early on Monday morning, eleven hours later, a car was rolled over the track. At 4.30 that afternoon, a locomotive weighing 281,800 lb. was coupled to the car and pulled over the slab.

DURING the past five years an increasing number of synchronous motors has been installed in steel works for various purposes, the largest to date being the 9000 H.P., 107 r.p.m., 6600-volt synchronous motor on main roll service in the continuous sheet-bar mill of the Corrigan-McKinney Steel Company at Cleveland, U.S.A. In this country synchronous motors are being used for various purposes, though starting difficulties have been experienced, for instance, on hydraulic accumulator work, and, while steel works engineers readily admit the economy of the synchronous motor, as regards its power-factor-raising properties, many of them have hesitated to instal it on account of the starting difficulties, preferring to use motors with high starting torques. In a large number of cases, however, the problem has been met by installing a magnetic clutch between a synchronous motor and the driven machine, the motor being allowed to run up to speed without load; the clutch is then engaged, and the load in consequence is taken up smoothly and without jar.

Miscellanea.

THE song of the oyster, which interfered with submarine signalling experiments off the American coast last year, is again causing interruption to tests off Hatteras, North Carolina. According to the *Wireless World*, the noise of the oyster resembles the sound of a person humming a tune.

THE Minister of Public Works for New Brunswick has awarded contracts for the metal superstructure spans of four new steel bridges which are to be erected in New Brunswick during the present season. These new bridges will be single, through, fixed, riveted steel trusses, ranging in length from 72ft. to 125ft. in the clear, with reinforced concrete slab roadway floor.

THE installation of wireless beacons round the British coasts is now in progress. Beacons at The Caskets and Start Point will be working in four months, and at Lundy Isle in about six months, and Parliamentary sanction has also been given to the erection, during the current financial year, of further beacons at South Bishop, Dungeness and Cromer, Sule Skerry, and Kinnaird Head.

ONE of the houses occupied by Newton when living in London stood on the corner site between St. Martin's-street and Orange-street, where the Westminster City Council is now erecting a new public library. The Council has decided to commemorate Newton's connection with the site by cutting an inscription on the stone face of the building to read as follows:—"Sir Isaac Newton lived in a house on this site, 1710–1727."

MECHANICAL and electrical plant for colliery purposes will be a dominating feature of the Manchester Colliery and General Mining Exhibition, opening on July 10th. The organisers have pursued the policy of specially inviting those who are intimately concerned with the colliery industry and who are interested and potential buyers. To this end, luncheons to the members of various technical associations connected with the industry have been organised.

THE report for 1927 of H.M. Inspectors of Explosives states that there were 56 accidents in manufacture, three resulting in six deaths. Only fourteen persons were injured. There were no accidents in magazines, stores, or registered premises. The year was the first completed year since the Petroleum Act, 1926, came into force. The majority of the 133 petroleum spirit stores inspected were very good, and none was classed as definitely bad. Thirty accidents, causing injury to twenty-six persons, were reported.

ON June 5th the Tyne Improvement Commission inspected the new riverside quay and shed which it has erected at Albert Edward Dock wall, North Shields. It will be publicly opened on June 15th. The quay is about 1100ft. long and is intended primarily to accommodate Norwegian mail and passenger steamers which hitherto have embarked and disembarked passengers at Newcastle quay. The new place of landing, which is 9 miles farther down the Tyne and near the harbour mouth, will be specially equipped for quick dispatch. A great convenience will be a direct railway service between the landing stage and King's Cross, whereas in the past passengers detrained at Newcastle and made the journey from the Central Station to the quay by motor or other vehicle. The quay is likely to increase the popularity of Norwegian tours by way of Newcastle, which affords the shortest route to Bergen.

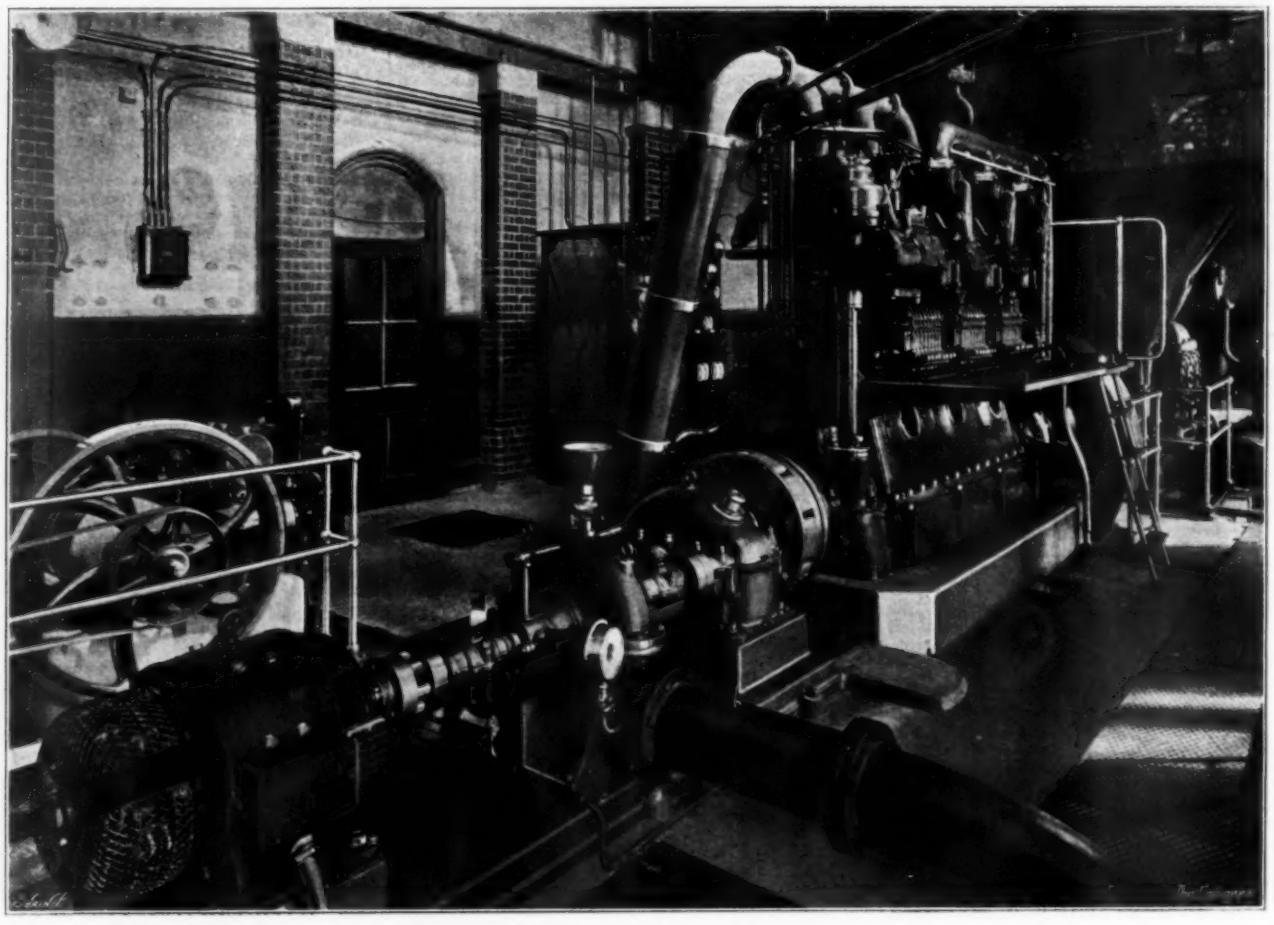
A NEW broadcasting transmitter is to be erected by the Marconi Company at Bucarest this year, the building of which will bring the number of countries in which such plant is being used up to twenty. The Bucarest station will be operated by a recently-formed national company to which broadcasting rights in Rumania have been ceded; its working wave-length has not yet been decided, but the transmitter has been designed to broadcast on any wave-length between 200 m. and 545 m. It will have a rating of 12 kW unmodulated energy to the aerial system, and will incorporate several new features of Marconi design. Before 1925 the use of private wireless sets was practically unknown in Rumania, but since the removal of restrictions a wide demand has grown up among amateurs and would-be listeners for a national broadcasting system; several wireless clubs have for some time been doing experimental work.

NEARLY 12,500 tons of salt were produced last year from Canada's only rock salt mine at Malagash, Nova Scotia, writes a correspondent. This represents an increase of 60 per cent. over the previous year's output, but is only a small portion of what will be produced when the company operating the mine has been reorganised, as is intended. Competent engineers state that there are 60,000,000 tons of absolutely pure white salt at Malagash, and 300,000,000 tons of a little lower quality, which can be transformed into the highest grade by the simple process of dissolving and evaporation. In view of its superiority to ordinary salt for fish curing, Nova Scotia fishermen use a large proportion of the Malagash salt. Thousands of tons, however, have been exported to the West Indies and elsewhere, while an increasing proportion is now being used in the Dominion for refrigeration purposes, and in the paper and steel industries.

THE Victorian Electricity Commission has ordered new plant for the briquetting factory at Yallourn, which will quadruple the present output and greatly reduce the cost of briquettes. The undertaking will cost in all £725,000. The extensions are expected to be fully in operation by 1930. Tenders have now been let for plant costing £264,000. The total cost exceeds the estimate by £10,000, chiefly due to preference being given to Australian manufacturers in the provision of certain parts. For the supply of briquette presses, driers, and cooling plant the tender from the German firm Zeitser Eisenengiesserei for £79,398 has been accepted. For the supply and erection of four boilers the tender from John Thompson, Ltd., Wolverhampton, for £185,301, has been accepted. The total value of new plant required will be £620,854, of which £364,233 will be expended in Australia and £119,800 elsewhere in the British Empire. The remainder will be spent on the briquetting plant, which is obtainable only in Germany.

RUMFIELDS PUMPING STATION—BROADSTAIRS WATERWORKS

(*For description see page* 617)



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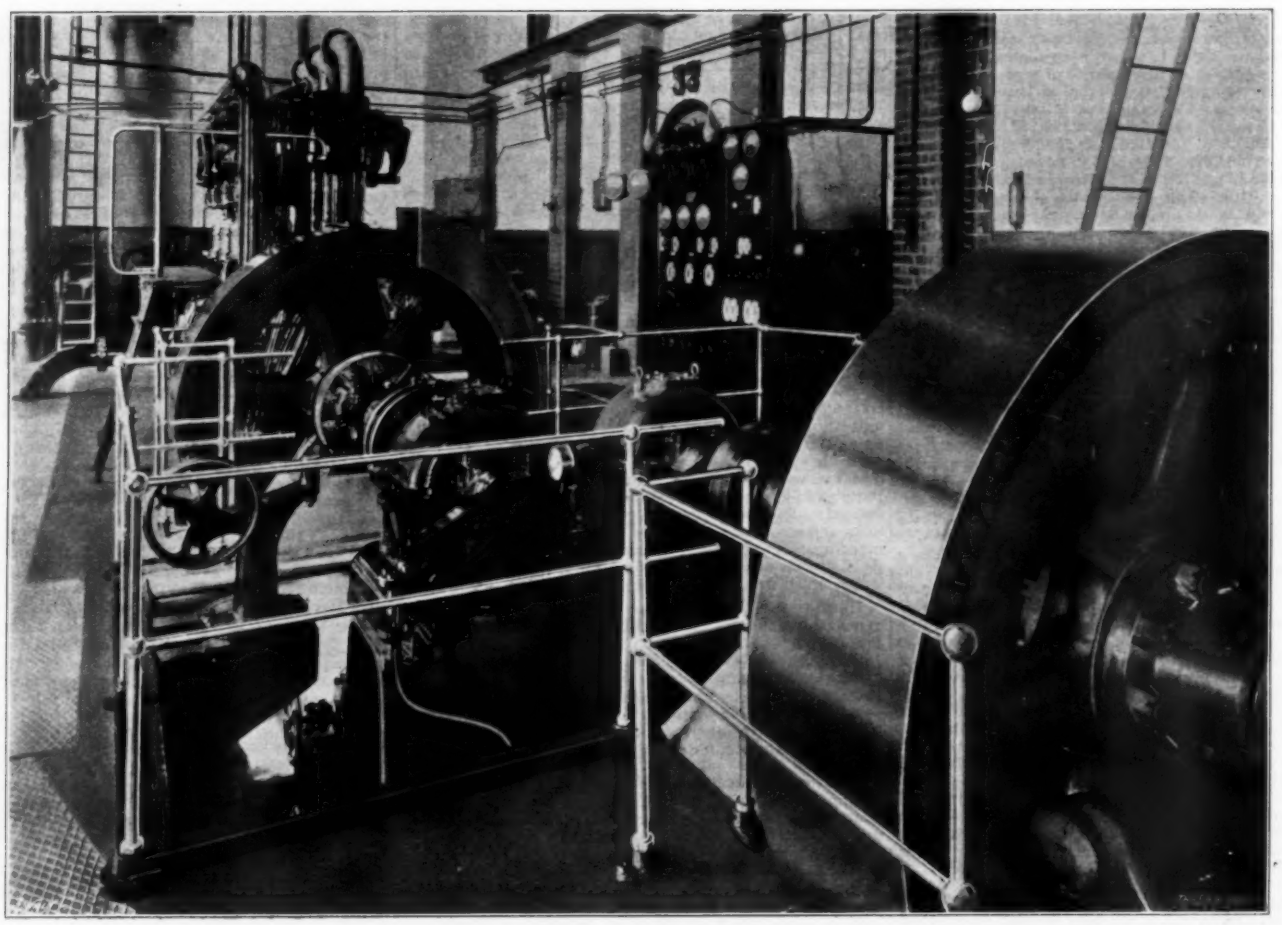

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DEATH.

ON June 2nd, at Colemans Hatch, Sussex, WALTER CLAUDE JOHNSON, M. Inst. C.E., in his eighty-first year.

THE ENGINEER.

JUNE 8, 1928.

A Century of Engineering.

THE Centenary Celebrations of the Institution of Civil Engineers, which have occupied the greater part of the present week, may be regarded as the conclusion of another chapter in the ceaseless story of engineering progress. When Tredgold proposed the famous definition which was used in the application for the Royal Charter in 1828 it seems not improbable that he took a more limited view of the functions of a civil engineer than that which, in succeeding years, his words have been made to support. The Institution has always shown a predilection for civil engineering, as it is now generally understood, and has since the coming of the Institution of Mechanical Engineers left—not entirely, but to a great extent—the consideration of mechanical engineering problems to that great sister society. Yet on such an occasion as the celebration of a century of engineering it was desirable that it should cover the whole field occupied by engineers, and all members of the profession, to whatever branch of it they may belong, welcomed the long series of papers, covering all manner of subjects, which were submitted for discussion on Tuesday and Thursday. Even more did they welcome the admirable "James Forrest" Lecture which Sir Alfred Ewing delivered on Monday evening. For his title Sir Alfred borrowed the famous "Century of Inventions" which the Marquis of Worcester gave to a book which has intrigued and puzzled engineers ever since its appearance in 1663. Worcester's "Century" was a description of a hundred inventions; Sir Alfred's, a review of the work of inventors, engineers and scientists in a hundred years. The Marquis, dealing with projects, was often vague and indeterminate; Sir Alfred was precise and definite, for he treated of things achieved, and rarely allowed himself the gratuitous error of prophesy. Yet if we may venture to differentiate between the parts of a lecture which was admirable throughout, we should say that it was just those which were imbued with what might be called prophetic reflections that made the greatest appeal to his audience. Especially the moving peroration in which the veteran engineer and scientist contrasted the spiritual degradation of the war with his vision of a time when progress would be directed towards the achievement of something more than the continued accretion of material amenities.

The sympathy with which these concluding passages were received by a large audience of engineers, an audience which was obviously deeply stirred by them, was an outward revelation of a sentiment which is, beyond all question, beginning to move in all classes of society and in all parts of the world. In the hundred years which ended in August, 1914, applied science had made strides unequalled in any preceding period, and, in the opinion of Sir Alfred, unlikely to be repeated in the future. But a few months later we beheld that very science employed for the destruction on an incredible scale of human life and property, and we saw let loose, nay even invoked as a necessary adjunct of war, the foul spirits of hatred and enmity and the legion of lesser vices which follow in their train. The world, despite its material progress, revealed itself as no better spiritually than in Gothic days, and even worse, for it turned to its hateful purpose those very things which had been devised for its comforts and its convenience. No wonder that Sir Alfred should have felt, as he told his audience, that the beliefs he had nurtured as a young man in the civilising influence of science and engineering were shattered, like a fair garden by an earthquake. But, we may ask, are we justified in measuring the spiritual progress of the world by its behaviour during a war? Is not that great malady akin to madness or to some violent fever in which the patient ceases to be responsible for his actions? Did not every nation involved in that awful struggle do things of which it was ashamed, and were not even the worst redeemed, in some measure, by the spirit of individual sacrifice for the good of many which inspired all the combatants? May we not go even further and ask, Had Germany foreseen the duration, and the horrors, and the magnitude of the maelstrom into which the world would be thrown, would she not have drawn back before taking the first step? If, instead of measuring the state of the world by its actions during the war, we measure it by its mode of thought before and since those feverish years, we are justified, we believe, in claiming that under the influence of science and the material benefits which engineering has conferred, the World has made some advance towards a better state. Squalor, dirt and epidemic diseases have been diminished; education has been extended; the narrow outlook has been enlarged; logical reason has replaced superstition; darkness has given place to light in homes, streets and factories; manual toil has been reduced, and the great sources of Nature have been directed in an extending scale for the use and convenience of man. It is impossible to believe that the great material changes effected by science and engineering have had no intellectual result and that man is really no further advanced than he was before they began. Rather are we inclined to the opinion that living, as he does, in the centre of the great development which is taking place, he is unable to observe it. If some Lecky or Buckle, or Draper or Spencer, or some great engineer and scientist, of a hundred years hence looks back upon the century through which we have just passed, will he not be able to record of it a greater, a more rapid intellectual growth than that which took place in the centuries preceding it? There would be cause for despondency, indeed, were we forced to surrender the faith, in which we have been brought up by a generation of great teachers; the faith that the search for knowledge and truth, which is science, and the useful application of our discoveries for the improvement of the lot of man, must in the end improve the intellectual status of the world and lead it nearer to the removal of those things which cause discontent and misery. For ourselves, we are convinced that "some power outside ourselves which makes for righteousness" stirs in the works of the scientist and the engineer, and that, despite the apparent relapse which the war revealed, the world is, in fact, being made better and wiser by knowledge and the application of knowledge to material purposes.

We are encouraged in this belief by the very fact that we see on many sides, in this country, in America, in Germany, in France, a growing tend-

ency to criticise the present attitude of the world towards progress, and to seek some higher, though still indefinite aim, in the advancement of science and engineering. That may appear paradoxical, but is not in fact, for the desire for the better shows that the good has already been attained. In America they speak of "service," which to our reserved British nature, always diffident about the expression of its feelings, sounds like cant, but is, we believe, a genuine effort to express a real moral tendency which defies close definition. In Germany the word is "culture," and behind it there is no doubt a similar attempt to express something which it is hard to define. Here we have no catch-word, but, as is usual with us, we are content with action, and we show by our extensive social and educational reforms the same desire to make the scientific and technical advances of knowledge contribute to the comfort and happiness of the community and to its intellectual improvement. It is not to be denied that progress brings in its train many difficulties; nor is it to be denied that one may pick out, here and there, many an evil that seems to have sprung directly from that progress; but take it for all in all the civilised portions of the globe are better places to live in than they would have been without the service of science and engineering, and if, by taking thought, they can gain more of the spirit, the intellectual and moral growth, the "ethical progress of the race," as Sir Alfred Ewing called it, they are destined to be better yet. We know not to what ends the applications of science under a great intellectual stimulus may lead us, but we may rest assured that they must slowly but surely increase the happiness and contentment of the world. We cannot go back to a former condition, we cannot throw our machines over a mountain side, we cannot surrender the scientific and technical advances we have made. But we can apply them to better purpose. The "collective moral sense, collective political responsibility, the divine maxim to do to others as we would they should do to us—these are lessons," said Sir Alfred, "in respect of which all natures, even the most progressive, have still much to learn." They are being learnt. The discontent with the present materialistic outlook is but the forerunner of the new spirit which philosophy is seeking; a philosophy which the engineer, through his vast influence in the modern world, can help to further, by united and international action, in an immeasurable degree.

Railway Accidents.

IN THE ENGINEER of October 14th last we had to take our contemporary *The Times* gently to task for an unnecessarily alarmist leader, ten days or so previously, on failures of railway equipment. We are prompted to revert to that subject by the appearance of the railway accident returns for 1927. Remembering the shockingly bad weather that was experienced in the summer and autumn of last year one of the first items in the returns for which we looked was the number of cases of flooding of the line and of slips. There were 169 instances of that character, as compared with the usual number of thirty or so, and the total was the worst, in that respect, since June of 1903 when the floods in East Anglia were mainly responsible for 123 floodings and slips on the Great Eastern Railway and for a total of 219 for all the British railways. The abnormal number of such incidents last year prepared us for a large increase in derailments, but we were agreeably surprised to find that the derailments connected with passenger trains were no more than 69 in number, as compared with 60 and 59 in 1926 and 1925 respectively; whilst the corresponding figures for freight trains were 184, 172 and 173—we add the numbers for 1925, because the usual comparison with the preceding year is hardly practicable, owing to the coal stoppage of 1926. There were, in 1927, 83 collisions in which passenger trains were involved, 115 freight train collisions, and 55 buffer stop collisions. The three corresponding figures for 1925 were 81, 124 and 59. Turning to the failures of equipment, we find that in 1927 the failures of machinery and springs of engines, the failures of tires of all classes, of failures of axles of all classes, and of broken rails were 31, 54, 77 and 185 respectively. Whilst these figures are slightly higher than those of 1925, and, of course, than those of 1926, they are lower than for any year since the war—we have not troubled to go further back. Failures of couplings were lower than in any year except the abnormal one of 1926.

It is not until Colonel Sir John Pringle's annual report is published in the early autumn that the best opportunity presents itself for commenting on the accidents of the year, but we know sufficient about them to say that the number inquired into by the Ministry of Transport was the lowest on record except during the war, when, owing to the greater value of the men's time, only the most serious accidents were investigated by the Board of Trade. Then, whilst the number—27—killed in train accidents was the highest since 1915, there were only four fatal train accidents, and two of those accounted for 25 deaths out of the total. On the other hand, only one servant was killed in a train accident, thus continuing the record in that respect established in 1925. Such figures furnish proof of the remarkable safety of British railways. It is difficult to submit any standard by which safety may be judged, but one item alone may give some idea. It is that the working of our railways is dependent upon the eternal vigilance of nearly 40,000 drivers and nearly 30,000 signalmen. A moment's wandering thought by a driver may lead to a signal being overlooked, and yet, though 260,000,000 miles were run last year, there were only four accidents of any note caused by drivers overrunning signals in clear weather, and four in fog. How rarely those 30,000 signalmen make a mistake is shown by the fact that they were directly or indirectly responsible for only four of the accidents whose cause was investigated last year. Turning from the operating to the engineering side of the question, we need not remind our readers that two of the outstanding accidents of last year were that at Sevenoaks and that, five days earlier, at Bearsted. A weakness of the track was evident in both those cases, but there were other unusual conditions besides the vile weather that made them exceptional and not truly representative. Then, there was one case of a signal failure—one among millions of signal movements in a year—and one of defective engine equipment. Actually, of all the accidents inquired into last year, the last was the only one that was indicative of want of administrative supervision. That remark leads up to our last observation. The greatest credit is, as we have seen, due to the men for the care they exercise, but behind all that lie their training, supervision, rules for working, well-placed signals, continuous brakes, track circuit, and many other items, provided to help the men in the efficient performance of their responsible duties. That is a feature on which British railway officers justly may take pride. Years ago many of them may have needed the spur of the Board of Trade, but it is safe to say that for the last thirty to forty years all such safeguards have been provided voluntarily and without outside pressure. The civil and mechanical engineers, too, have done their work efficiently, and their equipment has kept step with the development in material and manufacture. The combined result of the efforts of the officers of all the departments concerned, backed up by the admirable zeal of the men, have made British railways, in the matter of safety, the envy of the world.

Our main object in discussing the question of railway accidents on the present occasion is to offer the suggestion that in this country we have nearly reached the highest state of perfection possible, and that the accidents which now occur are only to be expected as part and parcel of the every-day life of a railway. What more can be done? It is true that last year's accidents furnished seven cases in which the Ministry of Transport officers held that automatic train control might have been useful. Agreed that such was the case, we would point out that since six accidents in 1922 there have never before been more than two or three a year. Then, the other day, and therefore not in last year's accidents, there was a broken carriage axle, and an electric test for hidden flaws was recommended. The remedy may be quite a suitable one, but there were only two failures of carriage axles last year, neither of which was thought to warrant an accident inquiry. Track circuit is another feature that often figures in the recommendations at the end of an accident report. The companies have, however, done so much in that direction that only once was it recommended in an accident report last year. Other illustrations could be given, but we have said enough. It is not our desire that the companies should in any way relax their attention to the provision of safety appliances nor that the powers in that respect enjoyed by the Ministry of Transport should be modified. What we wish to see is a general recognition of the truth, as regards the railways of this country, of the saying that despite the best arrangements that can be devised by the wit of man "Accidents will happen."

Literature.

James Watt and the Steam Engine. The Memorial Volume prepared for the Committee of the Watt Centenary Commemoration at Birmingham, 1919. By H. W. DICKINSON and RHYS JENKINS. Oxford: At the Clarendon Press. 1927. Price £3 3s.

So much has been written about James Watt and his work that it might well be thought that nothing more remained to be said. The authors of the present volume, both celebrated for their knowledge of the history of engineering, have, indeed, gone once more over all the old material; but they have winnowed and sifted it and extracted the last atom of information from it; they have filled in some missing links in the history of the inventions associated with Watt's name; have revealed a little more of the rich industrial period in which Watt lived; and have analysed more fully than ever before the character of their subject. It is doubtful, indeed, if anything more now remains to be discovered; anything, that is, that would be of real interest save to the antiquary whose prying eye is not satisfied as long as the smallest problem remains unsolved. We may, surely, regard this, then, as the "definitive" life of James Watt.

It opens with seven chapters under the general heading "James Watt, the Man." In this part of the volume, in which we see the hand of Mr. Dickinson, Watt appears in a rather new light. Smiles, in his "Life," and Arago in his famous "Eloge," treated him as a hero, and we have been brought up to think of him as a great man handicapped entirely by ill-health and poverty; rather, let us say, the victim of adversity than of his own faults. Mr. Dickinson presents him without heroic trappings; a man like other men, with the common weaknesses of humanity. Not always a very pleasant man, sometimes even, shall we venture to say it, ungrateful and even inconsiderate, given up not infrequently to black despondency, rather ready to bear ill-will to those opposed to him, and lacking sometimes in concentration. It is thus we are shown him for many years of his life, struggling upwards, made a little sour, perhaps, by adversity and illness. Then in his old age, when, at length, success has come to him, we see him with that beneficent and kindly face, dignified by troubles endured, and made wise by the careful pursuit of knowledge, which shines out in his later portraits—of which a splendid example by Sir William Beechey is admirably reproduced—and in the wonderful Chantry statue which his son erected to his memory in Handsworth Church. That is as it should be. The character of a great man is not lowered in our eyes if we know of his faults and weaknesses. They bring him closer to us, they make him more nearly one of ourselves, and our admiration is increased when we see that though hampered by common human defects he overcame them.

Very early in the book we come across an arresting sentence. Mr. Dickinson is insisting that for many years of his life, right through his "inventive days," Watt was not an engineer. He became one later, just as Boulton did, under the training of the Soho Works. But until that time—that is to say, well into middle life—he lacked, not only engineering knowledge, but even the engineering instinct. "It is perhaps," say the author, "not too much to say that it was fortunate that Watt had no engineering training at the commencement of his work on the steam engine and was thus incapable of appreciating the full force of difficulties that might have daunted a more experienced man." Upon that theme much might be said. It must be remembered that Watt, unlike some of the later pioneers of the steam engine, was not even a mechanic. He was an instrument maker and a surveyor, and became an engineer almost by chance. If it had not been for the model Newcomen engine he might have remained a surveyor to the end of his days. Even after he had invented the separate condenser he dallied with it as a dilettante might; he did not throw himself into its development heart and soul as Trevithick did into the high-pressure engine or Stephenson into the locomotive and railways. Had it not been for Boulton, Watt might have remained to the end the inventor of a great "principle," not the engineer of a great machine. One may almost say that Boulton forced him to be an engineer.

The Newcomen model came into Watt's hands in 1763, when he was getting on for twenty-eight years of age. For two years he struggled intermittently with the cause of its high steam consumption, and entered upon a really scientific investigation of the properties of steam. Then on a Sunday afternoon in 1765 the idea of the separate condenser came to him. He was not in a position to build a full-sized engine, but "even had he been so it is likely that in the absence of some driving force behind him he would have continued indefinitely producing models of one scheme after another." In 1767 Dr. Roebuck, as every one knows, provided the driving force. An engine was made; but it refused to work. Roebuck failed financially, and at that point the engine might have remained had not a new impulsive force been exerted on the inventor. Even then several years were wasted, and it was not till Boulton got both Watt and his engine to Birmingham, not without difficulties, that progress began. The Roebuck engine

was removed from Kinneil to Soho, and in 1774 it was made to run satisfactorily. Thus practically ten years elapsed between the invention and its fruition. For this delay there can be no doubt that Watt himself was largely responsible. He had married in 1764, and by this time had a family to support. The interest in research which had absorbed his attention during the early years of his married life had, perforce, given some place to that of making both ends meet, and he had to devote no little time to civil engineering and surveying just to "keep the pot boiling." He even considered in 1770 an offer to become Master Founder of Iron Ordnance to her Imperial Majesty Catherine II. of Russia, but had the discretion to refuse the invitation on the grounds, surely a prompting of the gods, that he was "advancing in the estimation of mankind here as an Engineer." A couple of years later, when the construction of the Midland Canal had stopped from lack of funds and Dr. Roebuck's resources were drawing to an end, so that experiments on the engine could not be pursued, Watt wrote to Dr. Small a letter which contains a very remarkable estimate of his own character. He wanted Small to induce Boulton to take a share in the engine, but did not wish to enter upon an agreement with the Birmingham manufacturer under anything approaching false pretences. He wrote therefore: "Remember, therefore, in recommending me to business that what I can promise to perform is to make an accurate survey and faithfull report of anything in the engineer way; to direct the course of canals, to lay out the ground and to measure the cube yards cut, or to be cut; to assist in bargaining for the price of work; to direct how it ought to be executed. . . . But I can on no account have anything to do with workmen, cash, or workmen's accts, nor would I chuse to be bound up to one subject that I could not occasionally serve such friends as might employ me for smaller matters. . . . I have no great experience and am not enterprising, seldom chusing to attempt things that are both great and new. I am not a man of regularity in Business and have bad health. Take care not to give any body a better opinion of me that I deserve, it will hurt me in the end." Take it for all in all, this is a delightful passage. Had it occurred in the pages of an acknowledged "diarist," a Pepys or Evelyn, the world would know of it. But Watt was just an engineer; and the world of literature cannot believe that engineers have the finer feelings of other men.

As an estimation of his own character, Watt was not far wrong in what he wrote. He was not—at that time—in any sense a business man, and, when we look at his life from the point of view put before us by Mr. Dickinson, we are forced to the conclusion that he was not "enterprising." At this period of his career he seems to stand out as a man of little more than ordinary intelligence, who, partly by opportunity and partly by hard thinking, has hit upon a good idea and has not the overpowering belief in the idea and in himself to thrust it upon the public. The world is full of such men; full of inventions which were never brought to fruition because the inventors had not unbounded confidence in them, or because they suffered from that diffidence which prevents some men from inducing others to risk their money in doubtful ventures. Watt was half-way between the two—those who can coax money out of the pockets of the rich and those who are too retiring, too timid even to make advances. He, we may say this with certainty, would never have brought the condensing engine to perfection without the help of friends who had more belief in it and in him than he had himself. To Roebuck, in the first place, and to Boulton, in the second, the world owes as deep a debt of gratitude as to the great inventor himself.

We are tempted to dwell upon that astounding period which opened with Watts entry into the Soho works, and which saw the development of traits in his character which his earlier life had not foreshadowed—traits which we may believe were inspired by business—and finally those long days at Heathfield, when, with his struggles behind him, he returned to the experimental period of his youth, and in his workshop, now happily preserved at South Kensington, devoted himself to invention and the culture of those qualities which endeared him to his family, and to all those, and numerous they were, who sought his acquaintance. Nothing is, perhaps, pleasanter in the whole life of Watt than its long quiet evening, when he found "satisfaction in the pursuit of new inventions, no longer as a business but as a hobby," when he collected around him young people to replace the old friends who had gone before him, and when he would still test his mental capacity by studying German once more, devote himself to quiet philosophy and hold a little audience entranced with his knowledge and experience. Some men die in harness, struggling with the world; others, Watt amongst them, are spared long enough to retire from the fight and to look back upon it with that calm which ensues upon a battle when the smoke, which still hangs over the field, merges both friends and foes in a softening cloud. Thus we look upon Watt in his last years, a great, a peaceful old man, of whom it may be said wholeheartedly, with his biographer, "no one has ever made a greater individual contribution to its (the steam engine) development, and furthermore that no such contribution has ever been fraught with so great import, for good or for ill, to the destinies of the human race."

At the VIII. Chapter the character of the book changes; we leave the man and enter upon a review of his works and inventions. Naturally it is far more technical than the part we have so far discussed. It opens with the Newcomen model and the invention of the separate condenser. Here we find the following delightful passage from a letter written on April 29th, 1765, by Watt to Dr. James Lind, of Edinburgh (Doldowlod papers). Watt had been at work with models of the separate condenser since the memorable Sunday on Glasgow Green, a few weeks previously, when the idea flashed into his mind. With a brass cylinder 2in. diameter and a foot long, he had satisfied himself that the steam would rush into a vacuum, and in his exultation and excitement he wrote as follows:—

"I have now almost a certainty of the facturum of the fire engine, having determined the following particulars; the quantity of steam produced; the ultimatum of the lever engine; the quantity of heat destroyed by the cold of its cylinder; the quantity destroyed in mine; and if there is not some devil in the hedge, mine ought to raise water to 44ft. with the same quantity of steam that theirs does to 32 (supposing my cylinder as thick as theirs), which I think I can demonstrate. . . . In short, I can think of nothing else but this machine." This appears to be the first contemporary documentary evidence of his critical experiments. It is followed by further letters to Lind and Roebuck, in which his troubles with models are detailed. His cylinders were not bored; they were of sheet metal hammered, and it is not surprising that he had a difficulty in keeping pistons tight; for many years he used oiled pasteboard with success. Unfortunately for the historian—or should we say fortunately, for your historian must have something to puzzle over?—Watt's contemporary letters were sometimes rather vague, and in later years his memory of his early experiments became shaky. Hence we cannot always be quite certain what he meant, and in this chapter the authors endeavour to settle some of the doubtful points. They are not of vital consequence perhaps but are of interest.

We have mentioned that Watt seemed sometimes to lack concentration. Here is a case in point. For two or three years he had been at work on the piston engine and was certainly approaching a practical point; it appears even that the construction of an engine had been begun. But just when success was at hand he suddenly took up the "circular steam engine"—his steam wheel—and for the next eighteen months the condensing engine was forgotten. Well may his biographers say, "indeed Watt would have made more definite progress had he not been quite so prolific in ideas." Early in 1768 he was, however, back at it again with a much larger model—7in. or 8in. diameter. It was into this cylinder that the mercury from the steam found its way and "played the devil with the solder." That mishap was soon put right, and from that point real progress was made. Roebuck began to press Watt to take out a patent, and arrangements for the construction of the Kinneil engine were entered into. It is of interest to recall here, in view of what happened later, that whereas Watt had seen that a beam was not a necessity, and had in consequence inverted the cylinder over the pump rods just as Bull did later, yet that when it comes to the design of an actual engine he employs the beam. "Perhaps," say his biographers, "he realised that he had set himself too big a task (the entire rebirth of the steam engine) and was constrained, as the line of least resistance, to adapt his invention to the existing beam engine."

The Kinneil engine was built and, as we have already noted, refused to work. With both Roebuck and Watt money was tight, and for many months Watt gave up mechanical engineering and devoted himself to surveying. The date of his famous patent is January 5th, 1769. The Kinneil engine was dropped in 1770 and in 1773 the metal parts were sent to Soho, where, in June, 1774, Watt began to re-erect it. Thus some five and a-half precious years in the life of the patent slipped away. Watt ascribes this very serious loss of time to Roebuck's financial difficulties and his own desire to pay off debts which weighed upon him, but it is almost impossible to evade the thought that a more determined, energetic and enterprising man would have found some means of avoiding the sacrifice of such a large portion of the life of a patent. We call attention to this point because it illustrates a comment which we have already made upon Watt's character.

With Chapter IX. the real history of the Watt steam engine may be said to begin, for in it we find full accounts of the rebuilt engine at Soho, the Broseley blowing engine for John Wilkinson, the pumping engine for Bloomfield Colliery, and the Bow, Bedworth and Colevile engines. Excellent drawings by Watt himself of the Bow and Colevile engines are reproduced in facsimile. In all these engines, Watt used what we may call the Newcomen cycle. That is to say, steam was admitted for practically the whole length of the stroke below the piston. The piston, indeed, had steam on the top-side as well, which Newcomen's engine had not, but as the gauge pressure was negligible, the cycle remained practically unchanged, save that condensation was effected in a separate vessel. Watt, however, had before 1769 foreseen the advantage of an early cut, and when the adoption of independent valves for admission and exhaust had made the design of an expansive engine relatively easy, he returned to that principle. Hence in 1777 a second engine—with a 33in. cylinder arranged for expansive working—was begun for Soho and was completed before August of that year. It was violent and cantankerous in its action, and was nick-named "Beelzebub." Again Watt proved indolent and indifferent. When "Beelzebub" failed at once to do what he expected, he lost interest in expansive working, and we find him suggesting that throttling was just as good. It was Boulton who stuck to the new principle, and it is to his pertinacity that the wicked old engine of 1777 changed its name, and became in later years "Old Bess," under which name it now resides, after many vicissitudes, at South Kensington. Boulton, not Watt, was the Petruchio to this Katherine. However, Watt had some justification for his attitude; the world was not ready for expansive working, and his biographers point out that as late as 1784 it had "ceased to be regarded as of any consequence."

It is interesting to note that Boulton's influence is again evident in the next important step, certainly the most important step in the progress of the steam engine. Years before this time, Watt had foreseen the possibility of building a double-acting engine, but he was too busy with affairs in Cornwall to give much attention to it. But both he and Boulton had some glimpse of the future of the rotative engine, and when Pickard succeeded in patenting the crank—against all reason—they saw that something had to be done. So we find Boulton, with real mechanical instinct, writing to Watt in 1781, proposing that he should revive his double-acting engine because "you might by that means turn a crank completely round the circle and then we are secure because a Com^{n} engine can't be made to work up and down." Watt did not, apparently, adopt the suggestion at once, but by March, 1783, "an up and down reciprocator" was at work at Soho. It used a rack and toothed sector on the beam end, as, of course, a chain could not be employed. It is plain that this gear did not appeal to Watt, and in June, 1784, he made the first models of his straight-line motion, which was later to develop into the parallel-motion, surely one of the most beautiful mechanical devices that the wit of man has evolved. He then set about circumventing Pickard's patent, and in 1782 described the sun and planet gear in a letter to Boulton.

The story of the crank is one of the most remarkable in the history of patents, and the chapter on it is by far the closest inquiry into the whole matter that has ever appeared. The use of the crank was well known at the time, and Watt apparently thought that it was open to anyone to use it. He himself had made a drawing of a double-cylinder engine with cranks at right angles several years before Pickard secured his patent. The surprising fact is that neither Watt nor Boulton nor anyone else had foreseen the part that a fly-wheel would play in a crank engine. Everyone had been busy with pumping engines which required a straight up and down motion, and in which variations in the length of stroke did not matter. Moreover, the engine could dwell at the end of each stroke. But the rotative engine presented very different problems. The fixed length of stroke was a standing difficulty. Watt tried to get over it by the use of a ratchet gear, but that was inherently bad. The crank and fly-wheel was the obvious solution, and we can understand his irritation when he found that he was debarred from the use of that combination. Possibly that irritation was augmented by a feeling that he ought to have foreseen the invention and secured it himself.

With the introduction of double-action and rotative motion the beam engine may be regarded as having attained its zenith. Other inventions were to be added to it, notably compounding, but to all intents and purposes it had then reached its limit. Nothing more could be done to change the general character of its design. But much remained to be effected in the improvement of its parts. The valve gear had exercised the ingenuity of Boulton and Watt and that master mechanic Murdock all through the progress of the engine, and by successive improvements had been brought practically to a standardised form. The valves themselves had reached perfection, and the biographers are able to show by some admirable plates that as far back as 1783—long before Murdock's patent of 1799—drawings of rectilinear sliding valve had been made at Soho. With the rotative engine came the need of speed regulation, and Watt, borrowing the idea from the "tenter" gear of the Albion Mills, applied the "whirling" governor to the steam engine somewhere about 1788. It may be regarded as the last of Watt's great inventions connected with the steam engine. His name is sometimes associated with the indicator, but wrongly. What Watt meant by an indicator was a spring pressure gauge. The application of the moving board to it and the consequent closed indicator diagram is without doubt due to John Southern, who had joined the firm in 1781, and was Watt's right-hand man.

We might continue to fill pages upon pages of MS. culling notes here and there from this Aladdin's Cave of historical jewels. It is surely the most exhaustive biography of a man and a machine that has ever been written, and the Watt Centenary Committee is to be congratulated upon having found two authors who had the necessary knowledge, the endless

WOODBRIDGE ROAD GENERATING STATION—GUILDFORD

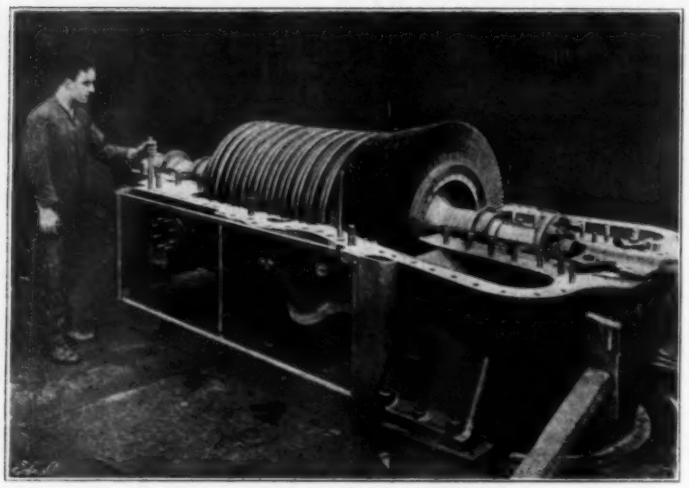


FIG. 6—1500 kW TURBINE WITH TOP OF CASING REMOVED

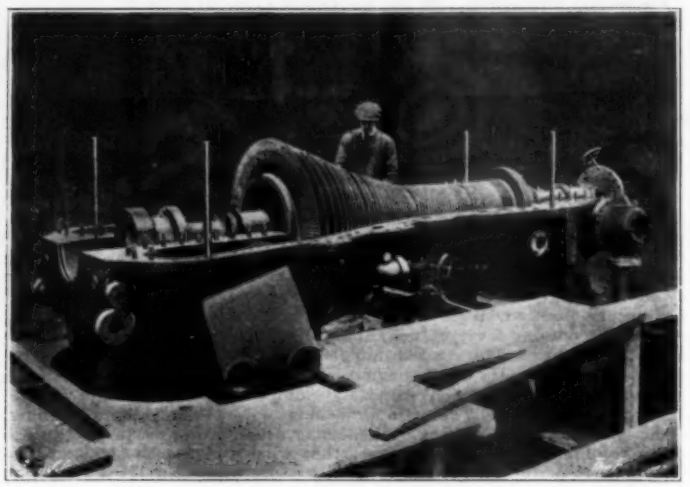


FIG. 7—3000 kW TURBINE WITH TOP OF CASING REMOVED

patience and the literary skill to bring such a volume to a happy conclusion. Neither must we forget the publishers, who have done their work in a manner that leaves nothing to be desired. The printing is admirable, the reproduction in facsimile of old drawings is perfect, and we have not in the whole volume come across a single erratum, great or small.

Following his biographers, we have endeavoured in this review of their great work to show something of Watt the man as well as of his inventions. We have seen that Watt was vacillating at times, and at times seemed to lack that enthusiasm, that "insanity of noble minds," which has driven other great reformers and inventors forward in the face of difficulties. We have seen how much he owed to his partnership with Boulton. It is indeed to the marriage of two great minds that we owe the development of the steam engine; Watt would not have done it alone, and Boulton could not. But in endeavouring to form any estimate of Watt's character we must ever remember that he had that diffidence and modesty which is so often found in the great, and that for the greater part of his life he laboured under ill-health. Criticise him as we will, his faults are insignificant by comparison with his merits, and we feel it an honour to subscribe to the words which Wordsworth used to Muirhead—another of Watt's biographers: "I look upon him, considering both the magnitude and the universality of his genius, as perhaps the most extraordinary man that this country ever produced; he never sought display, but was content to work in that quietness and humility, both of spirit and outward circumstances in which alone all that is truly great and good was ever done." He is as secure of perpetual memory in the minds of men as the great poet who used those words.

There are several monuments to Watt, but none finer, or more worthy of the man, than this Memorial Volume.

BOOKS RECEIVED.

Mine Lighting. By J. W. Whitaker. London: Methuen and Co., Ltd., 36, Essex-street, W.C. 2. Price 8s. 6d. net.

Journal of the Royal Agricultural Society of England. Volume 88. London: John Murray, Albemarle-street, Price 15s. net.

The Preparation of Coal for the Market. By Professor Henry Louis. London: Methuen and Co., Ltd., 36, Essex-street, W.C. 2. Price 10s. 6d. net.

Lion Aero Engines (Series V. and Va). Second edition. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 2s. 6d. net.

Telephone and Power Transmission. By R. Bradfield and W. J. John. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 21s. net.

Particulars of Meteorological Reports Issued by Wireless Telegraphy in Great Britain, 1928. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 4s. net.

The Aslib Directory: A Guide to Sources of Specialised Information in Great Britain and Ireland. Edited by G. F. Barwick, B.A. London: The Association of Special Libraries and Information Bureaux, 24, Bedford-square, W.C. 1. Price £1 1s. net.

THE New Brunswick Legislature has just passed a Bill giving consent to a project for the development of tidal power in Passamaquoddy Bay, an inlet from the Bay of Fundy. The scheme is international in character, as Passamaquoddy Bay is on the boundary line between New Brunswick and the State of Maine. In the Bay the rise and fall of the tide is within the range of 28ft., and the scheme proposed by Mr. Dexter P. Cooper, a New York engineer, contemplates the construction of dams and the bridging of various islands by means of which engineering works the tidal power will be used.

A New Electric Generating Station at Guildford.

No. II. (*Conclusion*).*

ALTHOUGH the total capacity of the Guildford power station is at present only 6000 kW, the consulting engineers, Messrs. May and Hawes, of Victoria-street, have taken advantage of all contrivances that tend to promote economy, ensure reliability, and reduce the cost of upkeep. De-aerating plant has been installed by Richardsons, Westgarth and Co., Ltd., and evaporators by Caird and Rayner, Ltd. All the most up-to-date instruments that help the engineer to obtain good efficiency have been provided in the boiler-house.

TURBINES.

The Parsons generating sets, although small as compared with many that are built in these days, are quite interesting machines. There are two 1500-kW sets and a 3000-kW machine, all designed for a speed of 3000 revolutions. The maximum continuous output for the two smaller units is 1875 kW; that for the large machine is 3750 kW at 0·8 power factor in each instance. Whilst the two 1500-kW turbines are built on the Curtis, Rateau and Parsons principles with impulse and reaction bladings, as shown in Figs. 6 and 8, the 3000-kW machine is a pure reaction turbine with a coned rotor, as illustrated in Figs. 7 and 9. The last row of reaction blading on the small units is 8in. high on a rotor diameter of 24in. On the larger machine the first blades are ⅜in. high on a rotor diameter of 14in., whilst the final blade height is 9¼in. on a rotor diameter of 28¾in. For the purpose of heating the feed water to a temperature of 180 deg. Fah. arrangements are made on each of the three machines for extracting steam at a pressure of about 15 lb. absolute. In the blading of all three machines stainless iron has been used. Radial clearance blading is employed on the reaction portion of the 1500-kW machines and on the last six rows of the 3000-kW set, but the remainder of the blading on this turbine is "end tightened." To enable the rotors to be examined for soundness it has long been customary at the Heaton works to provide the rotor shafts with an axial hole, and the three rotors for the Guildford turbines have been treated in this way.

GOVERNOR GEAR.

The governor gear fitted to the 3000-kW set corresponds with that on the 20,000-kW set built by C. A. Parsons and Co., Ltd., for the Schiehaven power station of the city of Rotterdam. The driving of the oil pumps, governor and tachometer is effected by a worm gear at the high-pressure end of the turbine shaft. The worm drives a horizontal cross shaft, at one end of which is the governor and at the other a pair of bevel wheels driving the vertical shaft for the tachometer and oil pumps. There are two oil pumps of the gear wheel type, both housed in the same casing. One of these pumps supplies the high-pressure oil for the oil relay gear; the other the oil for lubricating purposes. All parts are very accessible, and the whole governor assembly can be withdrawn by removing the end cover of its casing and without dismantling any other parts. The governing is very sensitive, as not only is the governor amply powerful, but all it has to do is to determine the position of a small balanced pilot valve that controls the admission of oil to the relay cylinder which operates the regulating valve.

The governor levers are machined and electroplated and the pins are case hardened and ground. At the extreme end of the turbine shaft is an independent overspeed governor, which shuts the machine down should the speed rise beyond a predetermined limit. This governor consists of a bolt which is normally held in position by a spring, but overcomes by its centrifugal force the constraint of the spring should the speed of rotation become high enough. Its head then projects from the shaft and strikes a lever which trips an independent spring-loaded run-away valve, and at the same time releases the oil pressure controlling the regulating valve. Steam is thus doubly shut off, as these two valves are in series on the steam flow. The overload valve is operated by the same mechanism that controls the regulating valve. When the latter valve is open sufficiently to pass all the steam coming into it, without restriction, any further opening would not, of course, serve to increase or maintain the speed of the turbine. The continued motion of the valve, however, under the action of the governor causes its spindle to act on the overload valve in the upper part of the high-pressure turbine casing by means of a system of levers. This valve, which is of the balanced double-beat type, is thus lifted from its seat, and high-pressure steam is thus allowed to pass from the inlet annulus of the turbine to a second annulus a little way along the rotor. By this means the first nine blade rows of the rotor are short circuited and put out of action, and the turbine will produce a greater power, though at a slight sacrifice of efficiency, because of the greater steam flow through the rest of the blading.

The principle of the governor gear for the 1500-kW sets will be understood from the drawing Fig. 10, which, in addition to the controlling governor mechanism, also shows a Parsons steam chest with a combined stop and run-away valve. An oil pump of the gear wheel type is mounted on the governor spindle next to the main or lubricating pump, and delivers oil at approximately 60 lb. per square inch through the relief valve body L to the underside of the relay piston to be seen on the left. Oil is also led from the relief valve body to the feed port in the governor casing M. This oil drains away through a leak-off port in the regulating sleeve N, the quantity of oil passing through this port being determined by the governor sleeve O. An increase in the speed of the machine uncovers more of the leak-off port, and as the pressure under the relay piston is then reduced the main valve spring forces the piston down and closes the double-beat valve sufficiently to bring the speed back to normal. The position of the regulating sleeve N can be altered by means of the hand wheel P. If the pressure in the system becomes too great the relief valve L opens and the oil drains away through the steam end to the end plate. In starting up, when no oil pressure is available, the governor valve is slightly lifted against the action of the relay spring by means of the usual hand lever and is temporarily held open by inserting the pawl R under the cross-head S. When, however, the governor takes control of the machine, the valve opens a little wider and the pawl R is released and falls out of position by its own weight.

The Parsons steam chest with combined stop and run-away valve is a feature of interest. The incoming steam is admitted under the valve A, the valve and lower portion of the spindle being in one piece, loosely connected to the screwed portion B which screws into the spring cap C. This cap is a sliding fit in the housing D, which is secured by the valve seat to the steam chest. A piece of hardened tool steel is let into the cap C and is provided with a notch for the reception of the trip spindle E which is kept in the notch by the torsion spring F, while the key G prevents the spring cap from turning. The top portion of the housing forms a dashpot and cushions the blow of the valve on its seat when it is released. When the trip levers are set, the stop valve

* No. I. appeared June 1st.

can be operated independently from the trip device; it can be opened and closed like an ordinary valve. Before opening the valve the by-pass valve on the steam chest must be opened in order to reduce the difference in pressure over the valve, and after that has been done the valve can be easily opened by means of the hand wheel. The by-pass valve must, however, be closed immediately the combined stop and run-away valve is opened, and a name plate calling attention to this fact is secured to the by-pass valve. When the valve A is open and the machine trips, the spring H in the steam end keep pulls over the lever J mounted on the spindle E, thus pulling the catch out of engagement. The main spring then forces the spring cap and spindle upwards, thus closing the valve. The trip levers may be set without reopening the valve by pushing in the knob K, as a slotted hole is provided in the lever train. This also allows the run-away valve to be closed down without disturbing the lever gear by means of the trip handle provided on the lever J. To set the valve after it has been tripped, the hand wheel is turned in a clockwise direction as if closing the valve, and this operation is continued, until the hand lever J on the spindle E takes up its normal position, the torsion spring F automatically setting the trip gear when the spring cap is in position. The direction of rotation is then reversed and the valve opens in the usual manner.

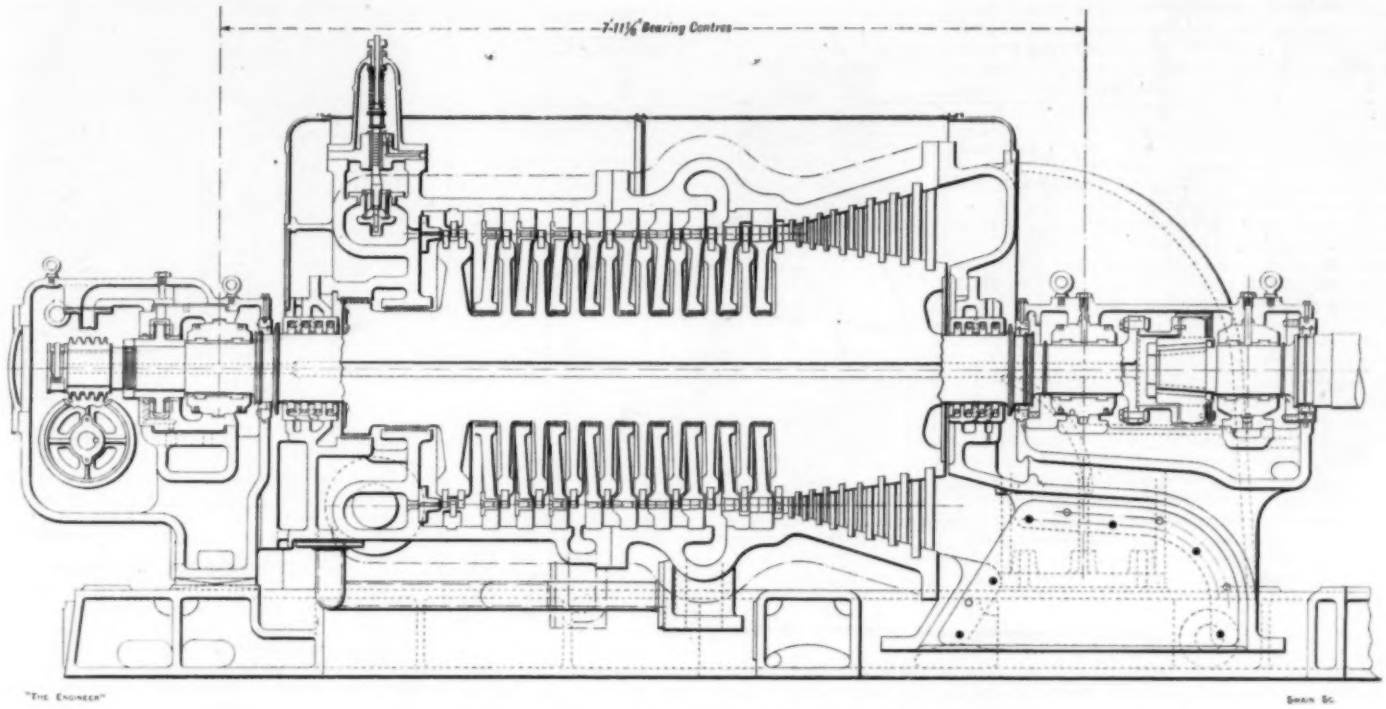


FIG. 8—1500 KILOWATT IMPULSE-REACTION TURBINE

EJECTOR AIR PUMPS.

Steam jet operated "ejector" air pumps, comprising a primary jet which exhausts into an auxiliary condenser and a secondary steam jet exhausting into a feed-water heater, are provided for the condensers of all the turbines. The modern arrangement of surface condensing plant, with steam-operated air ejector and separate contrifugal extraction pump, Messrs. C. A. Parsons point out, is a natural development of the "vacuum augmentor" principle instigated about 1903. The original Parsons patents Nos. 840/02 and 14,042/04 cover the simple vacuum augmentor with one steam nozzle, the use of a group of nozzles in parallel, so as to make the operating steam variable in amount and the use of nozzles in series, so as to compress the air by two or more stages. The arrangement of the original vacuum augmentor will be recalled from Fig. 11, where the main condensate drains from the main condenser through a "U" pipe towards the reciprocating air pump suction. At a point just above the level of the condensate in the main condenser, the residual air is extracted by means of the steam jet B in the augmentor C. The steam jet entrains the air by friction, imparting to it velocity energy, which is partly recovered in the form of pressure energy in the diffuser pipe D, leading to the augmentor condenser E, where the steam used by the nozzle is condensed, whilst the air passes on to the air pump suction. The pressure in the augmentor E is the same as that in the air pump suction pipe F, so that the action of the augmentor is to draw air from the main condenser and compress it to the ordinary pressure in the air pump suction, the result being that with an augmentor of suitable capacity for the amount of air to be dealt with, a considerably lower air pressure can be maintained in the condenser than in the air pump suction. The "U" bend in the main condensate drain pipe acts as a water seal pipe, and prevents the air in the air pump suction pipe from flowing back to a place at lower pressure, *i.e.*, the interior of the main condenser. By means of this single jet augmentor apparatus, an improved vacuum to the extent of about 2in. of mercury can be obtained without any increase in the air pump capacity, whilst the steam consumed by the operating jets entails an increase in total steam consumption of less than 1 per cent. The steam need not be taken from the main steam range, but from a point along the turbine after it has performed some useful work on the high-pressure blading. The augmentor condenser may be a surface condenser of the usual type or the augmentor steam may be condensed by actual contact with the cooling water, and in either case if the main condensate is used as cooling water, the latent heat in the augmentor steam will be conserved, so that the augmentor condenser also serves the useful purpose of a feed-water heater.

The natural sequence to the success of the vacuum augmentor is the replacement of the reciprocating pumps themselves by a steam jet operated apparatus, and this has been accomplished by using groups of steam jets in series, thus compressing the air in the condenser up to or above atmospheric pressure by two stages. When steam expands in a suitably shaped nozzle from an initial pressure P_1, a prodigious velocity may be attained, but if the steam is delivered into a suitably shaped reversed nozzle the jet may be slowed down again, and the pressure may thereby be regained. In practice, however, frictional losses are always present, and prevent the complete recovery of the pressure energy and, further, if, as in an air ejector, the steam jet is made to entrain air and carry it along with it, the steam particles will be still further slowed down, so that in practice there is a definite limit to the degree of pressure recovery attainable. In other words, the amount of compression or the compression ratio that is obtainable with stability is not very great, and it is found that nine or ten compressions are about the limit for a

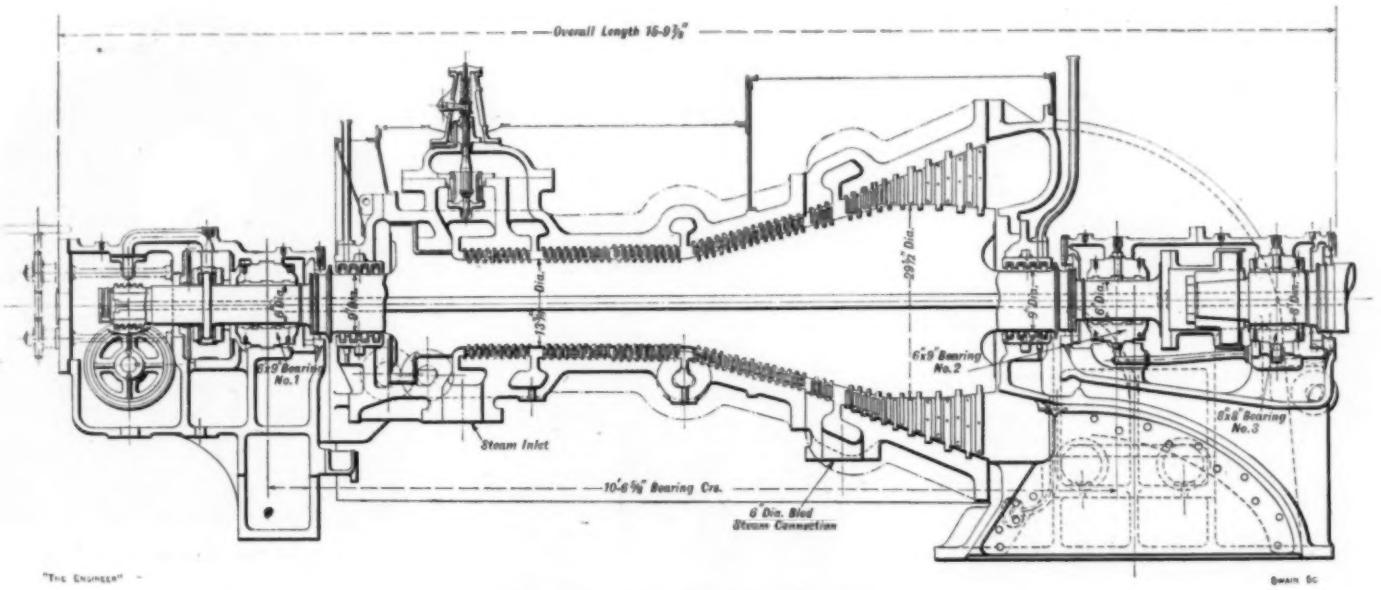


FIG. 9—3000 KILOWATT REACTION TURBINE

single stage. In practice, when it is desired to deal with a reasonable quantity of air for each pound of steam consumed, a ratio of about five or six is more suitable. Thus to compress a mixture of air and steam from a pressure of about $\frac{1}{2}$ lb. absolute and deliver the air against atmospheric pressure, requires $\frac{14 \cdot 7}{0 \cdot 5} = 29 \cdot 4$ compressions, so that the ratio per stage will be $\sqrt{29 \cdot 4}$, or about 5·4, the intermediate pressure being $(0 \cdot 5 \times 5 \cdot 4) = 2 \cdot 7$ lb. per square inch abs.

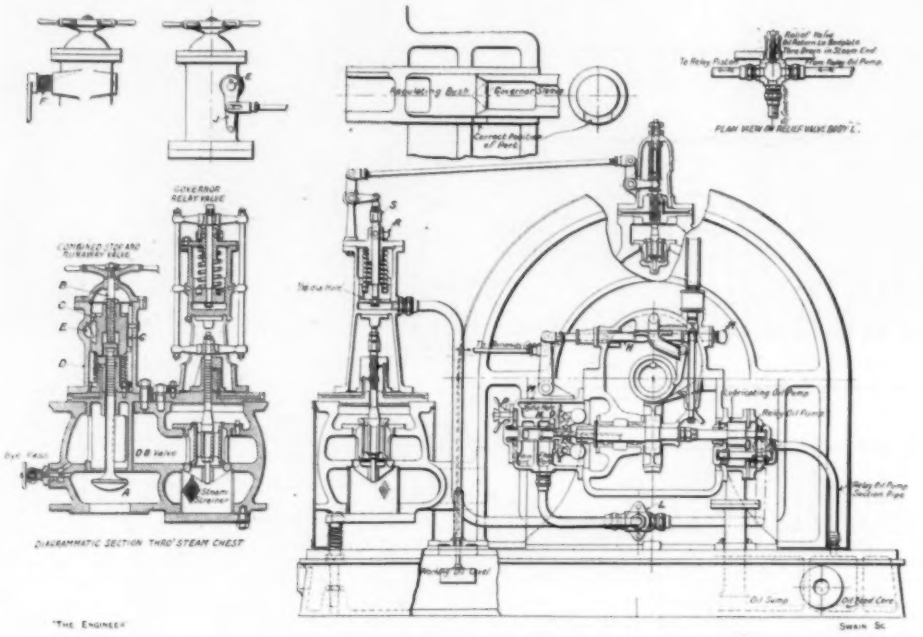


FIG. 10—GOVERNOR GEAR FOR 1500 kW SET

In the Parsons duplex air pump system the ejector is coupled up to the main condenser at the air extraction pipe A—see Figs. 12 and 13. The primary steam jet B_1—Fig. 12—entrains the air and delivers it into the mixing chamber C_1, after which the mixture of steam and air is compressed five or six times in the the diffuser C_2. If the compressed mixture were then entrained by a second nozzle, it could be compressed to atmospheric pressure, but this would entail an unnecessary consumption of steam by the secondary nozzle, because this steam would have to compress a mixture of both air and steam coming from the primary ejector.

Considerable economy of operating steam is therefore secured by the provision of an auxiliary condenser C—Fig. 13—which condenses the greater part of the steam from the primary nozzle, so that the secondary nozzle has a much smaller weight of air-steam mixture to entrain. This will be clear when it is considered that the function of the auxiliary condenser is to cool the steam received from the primary nozzle, and that the vapour pressure of this steam is thereby

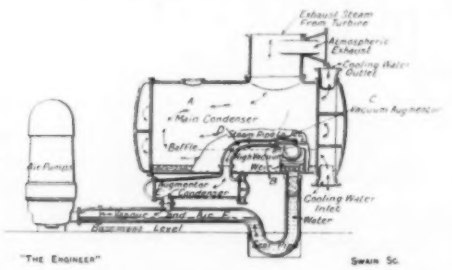


FIG. 11—ORIGINAL VACUUM AUGMENTOR

very greatly reduced. Condensation takes place, so that the air leaves the condenser practically freed from steam. Turning to the action of the secondary jet B_2 it will be seen from Fig. 12 that the operating steam and entrained mixture from the auxiliary condenser are discharged into the mixing chamber H, after which the velocity energy is partially reconverted into pressure energy in the diffuser H_2, with the result that the mixture is finally discharged at or above atmospheric pressure into the feed heater. The auxiliary condenser and feed heater are embodied in one casting—see Fig. 12—and in order to conserve the latent heat of the operating steam from the jets, the main condensate is used as cooling water.

Since the pressure in the auxiliary condenser is five or six times greater than that in the main condenser, it will be evident that, in order to get the condensate from the former to flow into the latter, a balancing column of water or "water seal" must be adopted, similar to that employed with the vacuum augmentor. It will be seen from Fig. 13 that the delivery pipe from the intermediate condenser C has an S-shaped bend at F. The condensate from C runs down into the left leg of this pipe, and the difference in pressure between C and G pushes the water column X Y up until it drains over at the top of the bend X, and so passes to the main condensers. Any residual air set free at X by the reduction in pressure is allowed to escape back into the main condenser by way of the pipe H, whilst the pipe K serves the same purpose in the case of the condensate extraction pump.

Referring to the main condenser, it will be seen that the air suction pipe leading to the ejectors leaves the condenser at a joint low down on its side, this being done in order that the air steam mixture drawn from the condenser may be as cool and as heavily charged with air as possible. A baffle is placed inside the condenser over the tubes in the neighbourhood of the air suction, so that the exhaust steam from the turbine does not have direct access to them. The cold cooling water entering the lower portion of the condenser first passes through these tubes, and so cools down the air steam mixture in the neighbourhood of the air suction.

GENERATORS.

Each of the three Parsons alternators generates three-phase 50-cycle current at a pressure of 6600

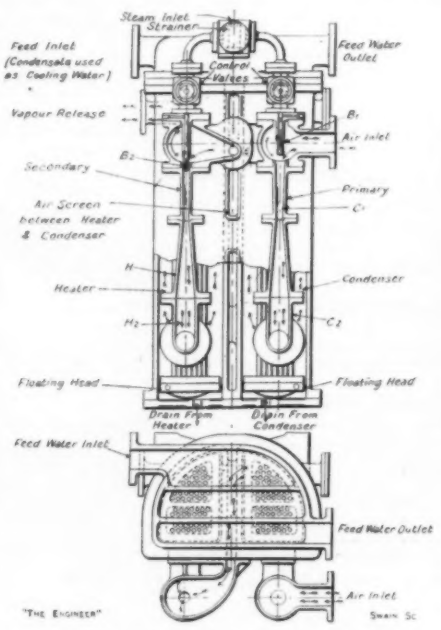


FIG. 12—STEAM JET VACUUM PUMP

volts. In accordance with modern practice, the rotor bodies are composed of solid steel forgings with the windings embedded in radial slots milled out of the solid, and as in the case of the turbine rotors, a hole is trepanned through each forging in order to allow of an inspection of the material in the region where flaws are most likely to occur. The exciters are multipolar shunt-wound machines, with interpoles and are overhung from the outer end of the rotor shaft. The stators for the 1500-kilowatt machines—see Fig. 14—are strip-wound on the involute principle, and each coil is interchangeable. Massive brass rings support the coils which are lashed to rings by means of cord. The stator of the 3000-kilowatt machine—see Fig. 15—is also strip wound, but is of the winding of the concentric type. In this case the windings are rigidly supported by substantial wood packings, and are very strongly clamped with massive brass clamp plates which enable the windings to withstand shocks caused by sudden short circuits or accidental faults on the external network. Sectional drawings of the 1500 and 3000-kilowatt alternators are given in Figs. 16 and 17 respectively; whilst Fig. 18 is an oscillogram of the voltage wave form between the line terminals of one of the machines. All the machines are ventilated in accordance with the Parsons closed-circuit, forced-ventilating system. Air is drawn in at

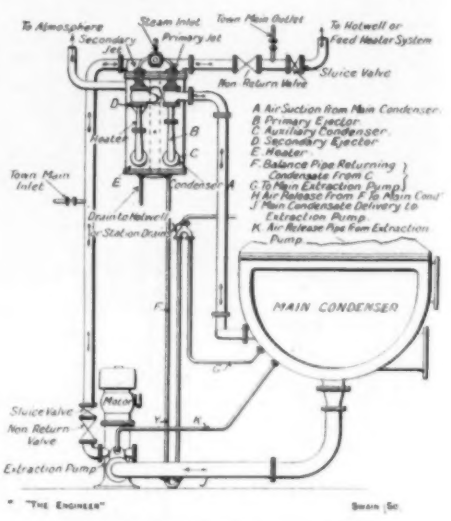


FIG. 13—CONDENSER AND PUMPS

each end of the alternator by means of an integral rotor fan, and having passed through the machine, it is discharged through the cooler, which is incorporated in the foundation block. On leaving the cooler, the cool air divides and is drawn in at each end of the alternator again, thus completing the circuit. Each cooler—see Fig. 19—is composed of two sections, each mounted on wheels and arranged to fit into guides in the floor and ceiling of the air cooler chamber. Valves in the water service pipes enable any section to be completely isolated and disconnected for inspection or for cleaning the tubes without putting the alternator out of service.

SWITCHGEAR AND TRANSFORMERS.

All the switchgear, which is metal-clad, was manufactured by A. Reyrolle and Co., Ltd., of Hebburn-on-Tyne, the design being such that it has been

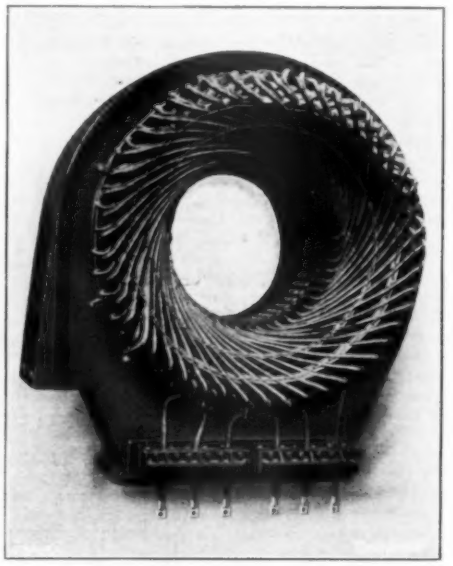


FIG. 14—1500 KILOWATT STATOR

possible to provide a continuous earthed metal enclosure for all the live parts of the control gear and cables which are armoured. As originally ordered, the main switchboard consisted of three 6,600-volt, three-phase, oil-immersed circuit breakers of the horizontal draw-out type for the three alternators, two for two 200-kVA Parsons transformers—see Fig. 20—for supplying current in the power station for the auxiliaries and lighting, two for outgoing high-tension feeders, and one for use as a bus-bar coupler, the switchboard being of the duplicate bus-bar type. Since the erection of the switchboard, however, it has been decided to add another feeder circuit breaker to control the supply to a section of the network near the power station. All the circuit breakers are of

ample size; in fact, they are suitable for an ultimate plant capacity up to 50,000 kilowatts, whilst their breaking capacity is 500,000 kVA. Protective gear of the self-balance type is provided for the alternators and standard Merz-Price gear for the transformers and feeders. The circuit breakers belonging to the main

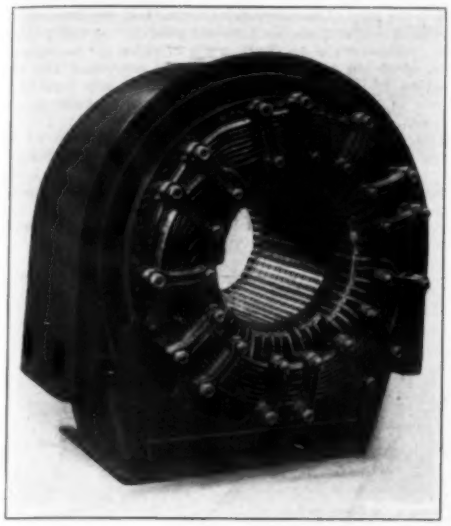


FIG. 15—3000 KILOWATT STATOR

switchboard are operated by solenoids energised from a control board which is fitted with the switches necessary for remote control, as well as an automatic voltage regulator for the alternators, voltmeters for indicating the station pressure, a synchroscope, a frequency meter, and other instruments, such as power factor meters, wattmeters, &c. For the three alternators, a neutral earthing resistance is provided, and it is coupled to the neutrals through three single-phase draw-out type circuit breakers, built together in a small separate switchboard.

The two transformer circuit breakers associated with the main switchgear are connected to the primary sides of the Parsons 200-kVA 6600/400-volt transformers shown in Fig. 20, whilst the secondary sides are coupled to the two incoming circuit breakers of a main distribution board, which controls the power station auxiliaries and lighting. The board is divided

FIG. 18—VOLTAGE OSCILLOGRAM

into two symmetrical parts, each consisting of one incoming transformer circuit breaker of the oil-immersed draw-out type, and two similar outgoing feeder circuit breakers. Normally, the two parts of the board are connected together by means of bus-bar links, but may be separated if necessary. Each of the incoming circuit breakers is provided with a voltmeter and an ammeter, whilst the other circuit breakers are provided with an ammeter alone. Two of the feeder circuit breakers, one in each part of the board, are at present spares, whilst the other two feed an auxiliary board, consisting of two incoming draw-out circuit breakers with a sectionalising circuit breaker between them, and twelve metal-clad switch and fuse unit boxes, which control the circuits to the individual distribution boxes for the various auxiliaries. Several of these circuits are used in pairs to give duplicate supplies to important points, so as to render the shutting down of auxiliaries a very remote possibility indeed. The dividing up of the main and auxiliary boards into two parts which are capable of being connected or disconnected as described, also provides security of operation. From the two parts of the auxiliary board duplicate circuits are run to the boiler-house, the engine-room, pump-house, the telpher motor, and

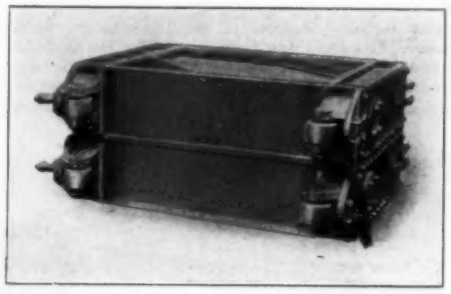


FIG. 19—AIR COOLER

to the lighting supply, whilst two remaining circuits feed a compressor and radiator. The cables from the twelve unit boxes are taken to metal-clad fuse distribution boxes, which supply the auxiliary and lighting currents. As the switchboard is metal-clad and the cables are armoured throughout, the possibility of breakdown is very remote, and the operators can perform their duties with safety.

Most of the sub-contractors who carried out work under the main contractors, C. A. Parsons and Co., Ltd., of Newcastle-on-Tyne, have been mentioned, but we should add that in addition to the mechanical stokers the Underfeed Stoker Company was responsible for the ash and coal-handling plant. The coal telpher was supplied by Babcock and Wilcox, Ltd.; the weighbridge by W. and T. Avery, Ltd.; and the auxiliary motors by the Lancashire Dynamo and

FIG. 20—200-kVA TRANSFORMERS

Motor Company, Ltd. In addition to the boilers, superheaters and economisers, the Stirling Boiler Company provided all the steel pipes, whilst the iron pipes were supplied by the Stanton Ironworks Company, Ltd.

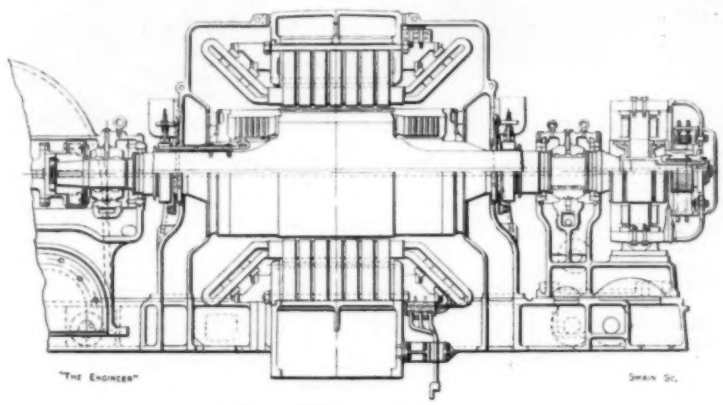


FIG. 16—1500 KILOWATT ALTERNATOR

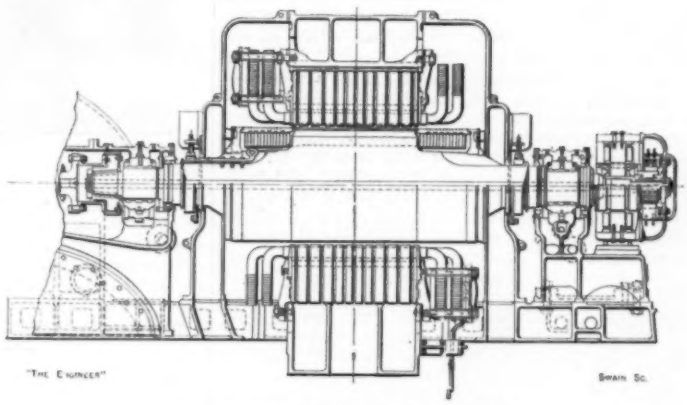


FIG. 17—3000 KILOWATT ALTERNATOR

The Institution of Civil Engineers.

CONVERSAZIONE.

In connection with the Charter Centenary Celebrations a Conversazione was held on Tuesday evening last, June 5th, at the home of the Institution, Great George-street. A very large company of members and guests was received in the Great Hall by the President, Mr. E. F. C. Trench, and Mrs. Trench, who were supported by the Council. The musical items included selections by a portion of the band of the Royal Regiment of Artillery, while Miss Isolde Menges contributed violin solos and Miss Jean Sterling Mackinlay songs. In what follows we give a brief description of the exhibits which were arranged for the instruction and entertainment of the visitors.

The London and North-Eastern Railway exhibited samples and photographs illustrating the evolution of railway rails. The early examples comprised a portion of a cast iron Outram rail, 1797, and a cast iron fish-bellied rail, 1816, both of which were carried on cast iron chairs fixed to stone sleepers. The next sample was a length of the company's standard present-day track. The fourth and last sample showed an experimental track consisting of ordinary standard rails mounted in ordinary standard chairs but with the wooden sleepers replaced by reinforced concrete blocks. There was one such block under each chair, and the blocks were tied together in pairs by light steel cross rods. We gather that this system of track is in accordance with Stent's patent. From a photograph exhibited showing the method of laying the track, it would appear that the concrete blocks are laid in groups of five pairs, each group being separated from the next by an ordinary wooden sleeper.

Dr. Telford Petrie showed a lengthy series of drawings depicting the history of the Lancashire boiler and other boilers similar to it. The earliest boiler of which a drawing was shown was a wagon boiler to work at 6 lb. per square inch, made by Fenton, Murray and Co., in 1840. Of the same or about the same date were a Cornish boiler by Swain and Boville, carrying 40 lb.; a Lancashire boiler by Petrie, of Rochdale, working at 32½ lb.; a Galloway boiler—maker's name not stated—carrying 25 lb.; and an egg-ended externally-fired boiler, by Rennie, working at 30 lb. Other historically interesting drawings included in the series were those of a 40 lb. multitubular boiler, made by R. Gordon in 1852; of an externally-fired boiler with five flues designed for 45 lb., and made by Fairbairn in 1853; and of an elephant boiler carrying 45 lb., and fitted with a chain grate stoker, made in 1858 by Hall, of Dartford. The series of drawings was completed by the inclusion of examples showing modern practice in the design of Lancashire, Cornish, and Galloway boilers.

Covering a well-filled table Hadfields Ltd. had an interesting collection of exhibits showing old and new objects in steel and iron. A series of projectiles extending historically from chilled iron shot to modern shells, and a section of the first Bessemer steel rail, made at Dowlais in 1856, were staged in proximity to some ornamental bowls and similar objects made of Hadfield's rustless nickel-chrome steel, and the rotor of an aero-engine supercharger, to work at 800-900 deg. Cent., made of the firm's heat-resisting steel. Another exhibit of historical interest was a piece of sheet iron from Murdock's original gasometer, constructed about 1798. This gasometer remained in use on its original site until 1911 at the works of Messrs. Avery, Soho, Birmingham. The specimen of metal was interesting, as showing the longevity of iron, even in thin sheets exposed to the weather, when protected by painting. An example of metallic longevity of another kind was represented by a thread-milling cutter of Hadfield's high speed steel, which had milled sixteen miles of screw thread in hard nickel chromium steel. The cutter was, of course, resharpened during the work, but as exhibited it was still not worn out and had every one of its teeth intact.

An exhibit shown by Professor E. G. Coker was designed to illustrate the suggestion made by Sir

David Brewster over a century ago, that the artificial double refraction produced in loaded transparent bodies might be used to find the stresses in arches, and also to illustrate the modern developments of this suggestion. The first apparatus exhibited showed what might have been accomplished in Brewster's time with glass models and a polarised field of light obtained by the aid of glass plate polarisers, and a source of light comparable with the resources available a hundred years ago. The second apparatus shown was an example of the latest form of optical bench constructed by Adam Hilger, Ltd., for the examination of transparent celluloid models of bridges and other framed structures. One of the models demonstrated was that of a two-pin arched bridge of an unbraced form sometimes used for reinforced concrete bridges. The model was loaded by means of a testing machine, which applied a deadweight at any required point of the bridge by aid of a plunger guided by annular diaphragms. The weight of the plunger was compensated for by an auxiliary spring. The stresses produced in the members of the bridge were measured by means of an auxiliary frame carrying a celluloid tension member, the load applied to which could be read directly on a new form of spring balance in which the elastic changes of a circular steel ring were used to measure the stress. The method employed to evaluate the stress in the loaded bridge model was to strain the tension member in the auxiliary frame until the colour transmitted by it neutralised, on superposing it, the colour transmitted by the bridge model.

Messrs. J. S. Wilson and W. Gore showed some models used twenty to twenty-five years ago to investigate the stresses in masonry dams. The models were made of indiarubber and were loaded to represent the water pressure by plates lying against the upstream face and pulled into contact with the surface of the model dam by cords to which weights were attached. The weight of the masonry was represented by hanging loads on pins passed through the centre of gravity of the blocks or segments into which the model was assumed to be divided. Measuring lines or circles were inscribed on the sectional face of the model, which was photographed in the loaded and unloaded condition. The photographs were subsequently superimposed, and the distortion of the lines and circles was measured.

The Central Electricity Board exhibited models of transmission towers for the 132-kilovolt "grid," and of a proposed outdoor 132-kilovolt sub-station. Mr. S. O. Cowper-Coles showed a working model of a process of rust-proofing iron and steel by forming zinc-iron and other alloys on the surface. Mr. A. E. Kidner showed a model of a 2-ton lifting truck with parallel motion link gear. Professor Joseph Husband exhibited the sextant used by Navigating Lieutenant James Kirke, R.N., during the voyage of discovery to the South Pacific Ocean in H.M.S. "Beagle," 1826–1830. By way of contrast, a modern sextant, by Cooke, Troughton and Simms, Ltd., was shown alongside the old one. Sir Alexander Binnie, Son and Deacon showed a rail and spike from the Penydarren "tramroad," South Wales, over which Richard Trevithick ran his first locomotive in February, 1804. The Science Museum was represented by a selection of models of pile-drivers, high-speed engines, hydraulic rams, shed structures, barrages and weirs, illustrating modern practice and the corresponding practice of one hundred years ago. The Museum also showed the original series-wound dynamo described to the Royal Society by Sir C. W. Siemens in February, 1867, and a Gramme dynamo of 1870, one of the earliest machines incorporating the ring type of armature invented by Pacinatti in 1860, and reintroduced with small modifications by Z. T. Gramme, a Belgian electrician. The Elder Brethren of Trinity House were also represented by a historical exhibit in which the evolution of lighthouse lighting equipment was exhibited from a Smeaton candle of 1759 to a 4-kilowatt gas-filled lamp. They also showed a model of the old Goodwin light-vessel of 1795, and contrasted it with a model of the lightship No. 81, stationed at the Royal Sovereign Shoals, and built in 1926. A third exhibit of historical interest was that of the Metropolitan Water Board, in which modern water fittings were contrasted with corresponding fittings of a former day. The Board also showed a sample of the elm water main as used in London before 1808, and a portion of a 6in. and an 8in. lead water main of the late sixteenth century.

Among a selection of books, manuscripts and other objects of interest from the Institution's Library, we noticed the Institution's first account book kept by the honorary treasurer, Mr. J. Jones. The first entry was dated December 24th, 1817, and was a charge of 11s. 6d. for the hire of a meeting room with waiter at Kendal Coffee House. On the facing page eight subscriptions of one guinea each were entered as having been received from the Institution's original members.

Two models of an arrangement of combined water-tube and Scotch marine boilers, planned according to Mr. J. Johnson's system for a geared turbine propelling machinery installation of 30,000 S.H.P., were exhibited by Yarrow and Co., Ltd., of Scotstoun.

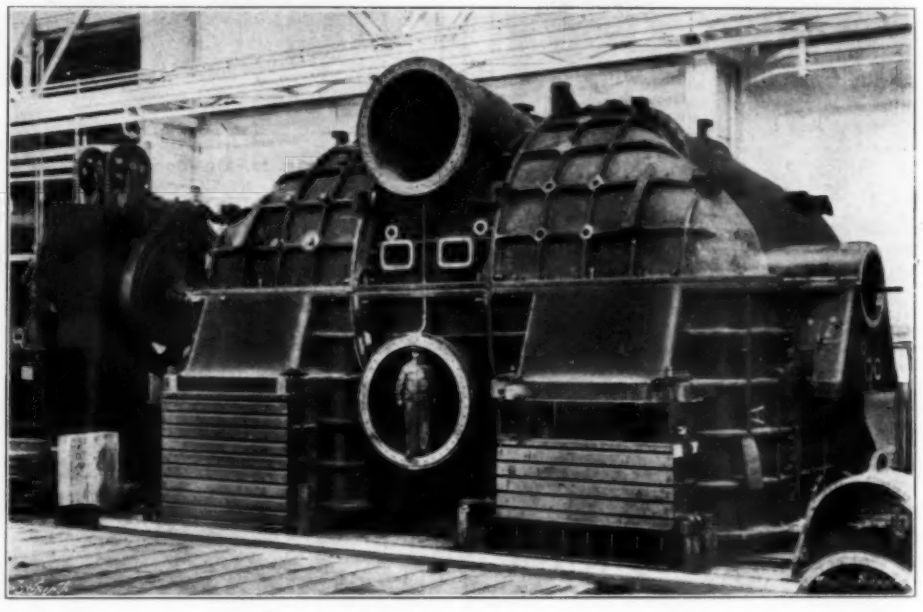
Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

HELLGATE POWER STATION, NEW YORK.

SIR,—You will recall that our organisation some short time ago received an order from the United Electric Light and Power Company of New York for a 160,000-kW turbo-generating plant for the Hellgate Power Station. A great deal of this set has been completed, and the balance is expected to be finished very shortly.

We send you a photograph, which we think will be of interest to your readers, of the low-pressure turbine cylinder. To refresh your memory, we give you the following brief particulars of the installation. The turbine is a cross-compound one, and comprises two shafts capable of delivering a total of 160,000 kW. The high-pressure set is designed for 75,000 kW at 1800 r.p.m., and the low-pressure one, of which the photograph shows the cylinder, will deliver 85,000 kW at 1200 r.p.m.



LOW PRESSURE TURBINE CYLINDER FOR HELLGATE

The weight of the complete plant will be 1150 tons, and the weight of the low-pressure cylinder shown in the photograph is 340 tons.

We hope the above details will be of interest.

BRITISH BROWN-BOVERI, Ltd.
R. L. MORRISON.

London, S.W. 1, June 4th.

LOCOMOTIVE DEVELOPMENT.

SIR,—I should like to point out an inaccuracy in the article on "The General Development of the Locomotive," appearing in the issue of THE ENGINEER of May 25th. In dealing with the "King Arthur" type of locomotive, the writer gives the impression that this was a new design superseding "Class 630," by which is meant, presumably, the four-cylinder simple engines of Mr. Dugald Drummond's design.

In point of fact, the large outside cylinder engine with outside Walschaerts' valve gear, was developed by Mr. Drummond's successor, Mr. R. W. Urie, from 1912 up to the latter's last design in 1918 before his retirement on the grouping in 1923. This last design—the "736" class—of which a general drawing was given in THE ENGINEER, appears to be identical with the "King Arthur" design, except in boiler pressure, cylinder diameter and valve travel. The boilers are interchangeable, and the general lay-out of the engine is the same in both classes.

It would thus appear that the "King Arthur"—rather than being a new design—is a development of an existing economical engine, and I hardly think Mr. Urie's *régime* merits such a complete omission from the records of locomotive development as the writer of the article referred to has presumed.

June 4th. SOUTH-WESTERN.

An International Test-Code for Steam Turbines.

FOLLOWING up the work accomplished by the International Electrotechnical Commission at its meetings in Italy last September, when agreement was reached regarding a tentative draft specification for steam turbines, a meeting of the Advisory Committee on Steam Turbines was held at the Hague, Holland, from May 21st to May 25th. An important feature of this meeting was the attendance of a large number of actual designers of steam turbines in association with important users, so that the technical discussions were very fruitful, as they could be carried a long way without any question of reference back on details, there being enough experts present to represent effectively the views of their national committees.

There was a marked degree of unanimity regarding the agreements on general principles, it being fully recognised that any international code can only permeate into the various national codes in proportion as the I.E.C. recommendations find favour with the individual countries for their own use. The Advisory Committee, recognising the inevitable differences in national practice at the present time, endeavoured to draft a set of rules for acceptance tests of steam turbines which would represent the best practice which all National Committees are invited to adopt as and when their national rules come up for revision.

The meeting clearly demonstrated the value of co-operation between the mechanical and electrical engineers, and completely vindicated the view that this work was within the province of the I.E.C. Eight out of the ten countries represented on the Advisory Committee sent delegates, the ten countries being the following:—Canada, Czecho-Slovakia, France, Germany, Great Britain, Italy Norway, Sweden, Switzerland, U.S.A.

The chair was taken by Professor Feldmann, President of the I.E.C., and Mr. C. le Maistre, the General Secretary of the I.E.C., was also present and took considerable part in the meetings. The British delegates were:—

Mr. J. P. Chittenden, English Electric Company, Ltd.
Mr. H. L. Guy, Metropolitan-Vickers Co., Ltd.
Mr. W. H. Patchell, consulting engineer.
Mr. I. V. Robinson, B.E.A.M.A.
Mr. T. Roles, Bradford Corporation Electricity Dept.
Mr. F. Samuelson, British Thomson-Houston Co., Ltd.
Mr. G. Stoney, C. Parsons and Co., Ltd.
Mr. M. G. S. Swallow, Richardsons, Westgarth and Co., Ltd.
Mr. J. F. Stanley, Assistant Secretary, British National Committee of the I.E.C.

The work of the I.E.C. in connection with steam turbines comprises the following three parts:—Part I., Specification; Part II., Rules for Acceptance Tests; Part III., Additional Items Required for Research Purposes.

Part I. was dealt with at the meeting in Italy last year, and the object of the meeting at The Hague was to consider the question of rules for acceptance tests. Specific proposals were submitted for consideration by the British, German, Czecho-Slovakian and United States delegates, the British proposals being based on the report of the Institution of Civil Engineers on Tabulating the Results of Heat Engine and Boiler Trials. These various proposals contained a mass of detailed information, and the work of the Committee was largely concerned with the task of collating the data available and assembling them into one comprehensive code.

In spite of the very specialised and complex nature of the subject, considerable progress was made, owing to the strenuous efforts of several Sub-Committees which were appointed to deal with specific aspects of the work. To facilitate the discussions the subject was divided broadly into seven sections, it being understood, however, that the final draft proposals for the rules for acceptance tests, when circulated to the National Committee for review, will not necessarily retain this rigid subdivision or sequence of sections. The seven sections in question are as follows:—Object and Scope; Definitions; Guiding Principles; Essential Measurements; Instruments and Methods of Measurement; Commutation of Results; Data and Results. Some of these sections were discussed in detail, while others were only considered from the point of view of broad principles, the drafting of the detailed proposals being left to the American Secretariat in collaboration with an Editing Committee consisting of one delegate from France, Germany, Great Britain, Switzerland, and United States of America.

It is hoped that a further meeting of the Advisory Committee will be held in about a year's time, in London, to consider the full draft of the International Rules for Acceptance Tests which will in the meantime have been prepared by the Secretariat and Editing Committee from the material agreed to at The Hague, and will have been considered by each National Committee individually.

An 80 B.H.P. Oil Engine for a Woollen Mill.

DURING the course of a visit to the works of Alexander Shanks and Son, Ltd., at Arbroath, we recently had an opportunity of inspecting under construction and on test a series of cold-starting oil engines working on the four-stroke cycle system with solid injection which the firm is now building. We have chosen for description an 80 B.H.P. single-cylinder unit which is one of the largest of the range of single-cylinder engines including nine sizes from 12 up to 105 B.H.P. Twin-cylinder units in six sizes from 64 to 210 B.H.P. are also constructed.

The engine shown in the accompanying engravings has run successfully during the last few months at the Seafield Woollen Mills of R. Laidlaw and Sons, of Keith, Banffshire, and embodies some interesting features in design. It has a normal output of 80 B.H.P. when running at 225 r.p.m.; while on test at the makers' works it developed 92 B.H.P. The fuel consumption at the working load was 0·39 lb. per B.H.P. hour, the fuel employed being a Scotch Diesel oil.

A side elevation of the engine, with a section through the valves at the breech end, are given in Fig. 1, whilst an end view of the engine, as installed in the mill, is reproduced in Fig. 3.

The bed-plate is of a deep girder pattern, and the main walls are carried up above the centre line of the cylinder. Eight foundation bolts pass down through the full depth of the bed-plate. The crank shaft bearings and also the side shaft bearings are ring lubricated. A six-point positive action lubricator, operated from the side shaft, is fitted, three feeds being led to the piston and one each to the crank pin, the gudgeon pin and the exhaust valve sleeve. All the reciprocating parts are enclosed in a casing which has an inspection door for examining the piston.

The cylinder bore is 15in. and the stroke is 24in. The side shaft is driven by spiral gears from the crank shaft, and from it the governor, the fuel pump and the air inlet and exhaust valves are operated. The valves, as will be seen from the cross section in Fig. 1, are mounted in a special breech end casting, which is provided with large water spaces for cooling. A single cam is employed to work both the air inlet and the exhaust valve. The exhaust valve is housed in a specially lubricated sleeve and the seating for it is renewable. It can be withdrawn upwards when the air inlet valve cage has been removed. Immediately above the air inlet valve is the air filter, which consists of a number of turns of rope wound round a slotted cylinder, the whole of the filter being covered by a circular hood. At the side of the engine is the starting valve which is mechanically operated from the side shaft, and is provided with a hand-operated control wheel. The fuel pump is made of steel, and is enclosed in a robust casting attached to the main frame of the engine. A section through the fuel pump is given in Fig. 1, and Fig. 2 shows the arrangement of the governor controls and the sprayer. It will be seen that the suction and delivery valves are of the ball type. The stroke of the fuel pump is kept constant, but the effective injection stroke is varied by the governor which alters the point at which the suction valve closes. The general arrangement of the governor controls is indicated in Fig. 2. There is a hand cut-out lever provided on the fuel pump which puts the fuel pump plunger out of action and prevents any fuel from being delivered to the sprayer. The governor is totally enclosed and is driven from the side shaft through a flexible coupling. It is designed to maintain the speed from no load to the full working load, within a limit of 2 per cent. The sprayer shown in Fig. 2 is simple in design, and facilities are provided for inspection and cleaning.

At the breech end of the engine there is arranged in the exhaust pipe a combined fuel heater and filter which receives its supply of fuel from the ready-use tank. The main fuel tank is designed to hold about 10 tons of oil, and a small hand pump is fitted to charge the service tank. Use is made of the hot water from the engine jacket for the washing of wool. The cooling tank is of moderate size, and it receives a supply of cool water from an overhead tank, the supply being so regulated that a jacket temperature of about 110 deg. Fah. is maintained. Arrangements are made whereby the engine can be started by compressed air, a small compressor driven by a belt from the crank shaft of the main engine being fitted. A small auxiliary engine is provided to drive this compressor in case of an emergency. Air is stored at a pressure of about 250 lb. per square inch in a receiver, from which a supply is taken to start the engine.

The main drive is transmitted through a friction clutch to the mill shafting. There is also a direct-driven dynamo for lighting the mills, and for this reason a specially designed 8ft. diameter fly-wheel, with a 12in. rim, has been fitted.

The installation has been worked out to give an economical supply of power to the mill, and we understand that the regularity of speed at changing loads, which is an essential factor in a woollen mill, has given great satisfaction.

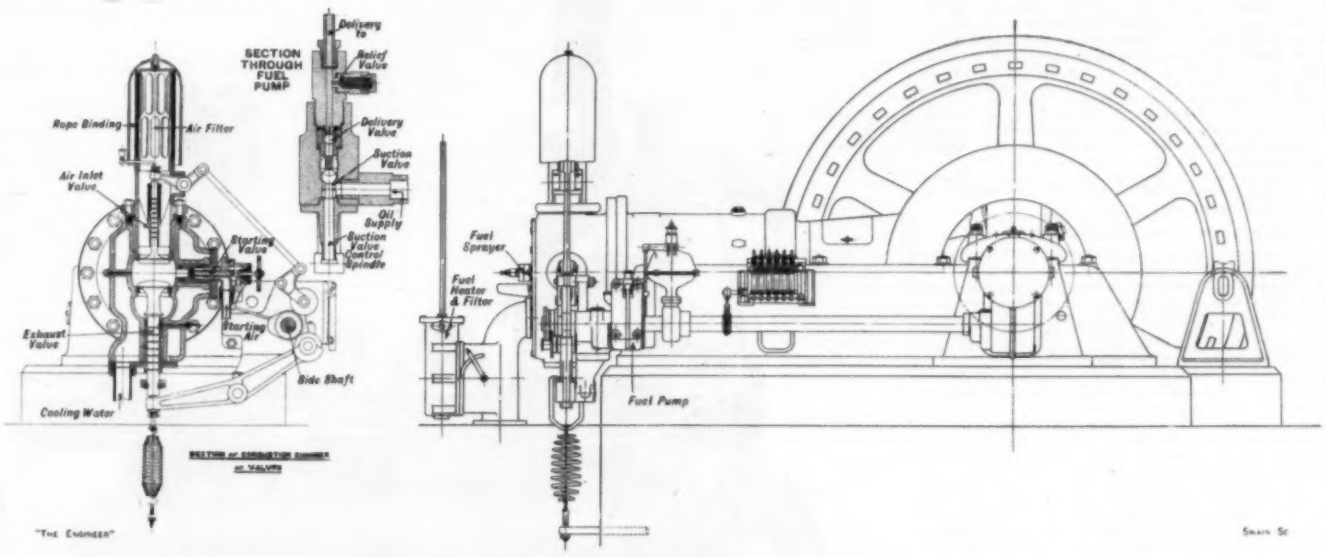


FIG. 1—80 B.H.P. SINGLE CYLINDER OIL ENGINE

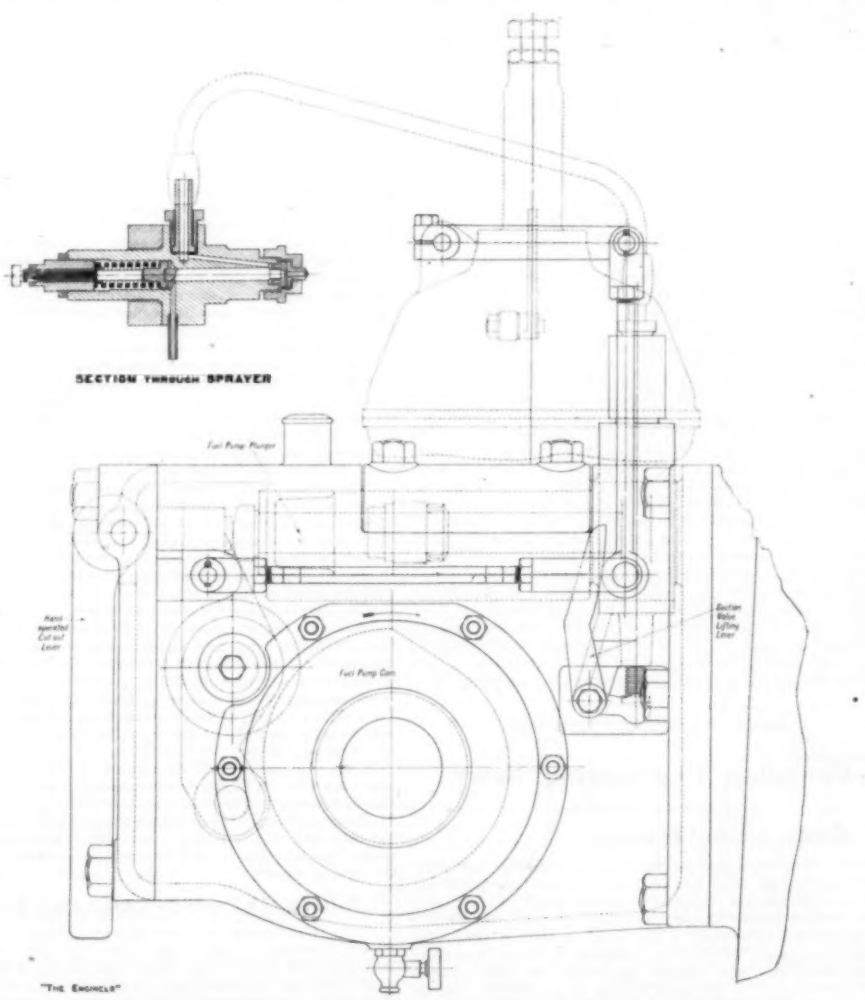


FIG. 2—SECTION THROUGH SPRAYER AND ARRANGEMENT OF GOVERNOR CONTROLS

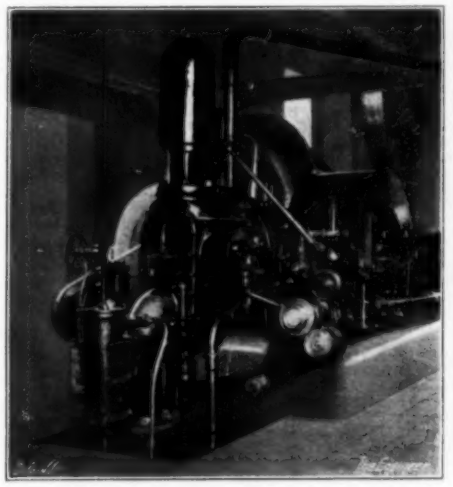


FIG. 3—80 B.H.P. OIL ENGINE

IT is announced that an order for two new turbine steamers for the Dover–Ostend route has been placed by the Belgian State Railways with the firm of John Cockerill,

The Institution of Civil Engineers.

APRIL EXAMINATIONS, 1928.—INTERIM PASS LIST.
PRELIMINARY (90).

W. M. Anderson, R. S. J. Ansell, B. F. Barber, G. R. Baxter, A. Boxall, F. Breakwell, A. Brown, C. V. Burn, D. M. Cannon, H. M. Carter, W. R. Champion, L. I. Clark, W. T. Collier, J. H. Contractor, H. G. W. Cook, R. T. Cooke, C. Cooper, D. S. Cran, G. S. Cullen, C. E. T. Curr, H. F. Daniel, E. F. H. D'ath, H. R. Davenport, N. P. Davies, E. W. Denholm, C. H. Downe, A. Downer, G. B. Dunlop, E. J. Ettles, F. Everitt, A. Fisher, W. P. Fleming, P. V. G. Ford, J. Forrester, R. E. Gardner, G. W. Haggis, M. Hamer, G. B. Hannay, R. E. Harris, R. F. Heaney, D. Y. Hill, F. Hodson, H. A. Hollyhurst, A. R. Jackson, J. M. James, J. Jamieson, jun., W. Kaye, S. S. Khanna, W. F. Lane, E. G. J. Lediard, W. E. Lewis, R. Lloyd, S. M. Lovell, M. N. Medrington, A. S. Moody, D. L. Morgan, M. F. Palmer, G. A. H. Philipiah, R. J. Rengifo, A. Reynolds, J. J. V. Rogers, R. Ross, J. A. Routledge, I. D. Scott, G. E. Sewell, R. M. W. Shaw, W. P. Shewell, W. H. Shoesmith, D. H. Smith, J. MacL. Smith, W. S. Smith, C. H. S. Spaull, J. C. Spurr, A. R. Stephenson, N. H. Stockley, A. Tassell, W. Taylor, A. E. Thomas, J. W. Turnock, R. A. Urquhart, J. K. Urwin, F. Waite, E. Walker, J. McL. Webster, W. F. White, A. C. Wildsmith, C. S. Willey, S. C. Wybrow, A. J. Wynne, W. Young.

ASSOCIATE MEMBERSHIP (230).

Whole Examination (Sections A, B, and C) (3).—W. H. G. Mercer, J. G. Paterson, J. Young.

Sections A and B only (20).—A. E. M. M. Azmy, A. L. L. Baker, B. S. Billingham, T. V. Burrows, H. C. Chatfield, jun., W. Dempster, R. M. Dymond, J. F. Fraser, H. C. Hampton, D. D. Kaila, J. B. McGaw, J. L. Macmorran, A. R. Pursell, E. Roberts, W. B. Shannon, G. C. Stubbs, S. E. Van Ryssen, J. S. Vigne, H. Wallhouse, J. K. C. Wilson.

Sections A and C only (2).—V. Johnson, J. McC. Lee.

Sections B and C only (10).—A. F. Benson, S. P. De Laszlo, A. C. Dunthorne, A. H. Freeman, J. H. Goodridge, C. L. Kenmir, A. C. L. Law, C. Lunn, C. W. Spencer, D. F. Young.

Section A only (34).—E. G. M. Allen, J. Andrew, H. G. Andrews, H. R. Anstee, C. H. Bunclark, W. F. Cartwright, G. H. Clegg, K. H. B. Collier, A. H. Davies, A. H. Gillard, W. Grant, C. S. Gray, S. C. Hardern, E. V. Hawkridge, K. A. Haynes, W. R. C Inkpen, W. B. Lyall, R. E. McCreadie, W. Morris, M. D. Nunn, A. Parker, A. N. Peters, W. H. Pink, A. W. Saleh, J. G. Smith L. G. Snow, P. G. W. Stokes, W. S. Stredwick, H. E. G. Stripp, E. G. Thorp, D. I. Todman, F. E. Turner, C. E. Watson, L. F. Weldon.

Section B only (24).—W. E. L. Adams, E. Adlington, A. Begleman, H. F. Commerford, R. M. Crichton, B. W. Davies, D. R. Errington, K. Fraser, C. H. Hales, H. L. Hammond, F. B. Hollis, R. A. Hutson, B. E. Ireland, H. Longton, D. E. Morse, H. Price, F. K. Sinclair, G. L. Stratton, C. E. H. Verity, K. Wahba, L. E. Williams, N. S. Williams, J. E. Wilson, J. H. Young.

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A High-pressure Turbine-driven Boiler Feed Pump.

IN the accompanying illustration we show a multi-stage turbine-driven boiler feed pump designed for high-pressure duty and recently supplied by G. and J. Weir, Ltd., of Cathcart, Glasgow, to the central power station of the Union Electrique de L'Ouest of Caen. The boiler pressure at the station is 25 kilos. per square centimetre, or a little over 355 lb. per square inch, and the pump was designed to work against a discharge pressure of 38 kilos. per square centimetre, or about 540 lb. per square inch. The pressure is obtained in two stages and the designed output of the pump is 58 cubic metres per hour, or about 128,000 lb. of boiler feed per hour.

The compact design of the pump, which combines rigidity with robustness of construction, is evident from the engraving. In general, it follows closely the firm's standard practice, and the turbine is of the impulse type, with a single-pressure stage followed by several velocity stages. The pump is of the two-stage ring section pattern. The impellers are made of "monel" metal, while the pump sections, turbine casing and frame are of cast iron with end covers of cast steel, in order to withstand the high temperatures and pressures at which the unit is called upon to work.

A chrome nickel steel shaft is provided, and it is fitted with non-corrodible sleeves where it passes through the pump glands.

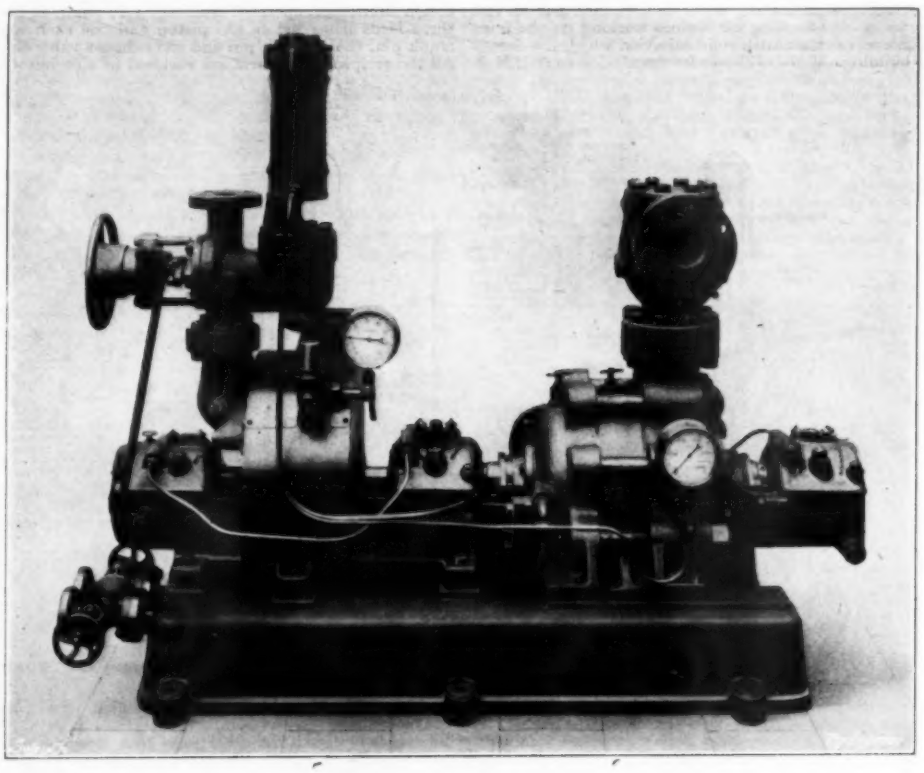
A feature of the design is the special water pressure chamber within the pump, the purpose of which is to balance automatically the end thrust at all loads. Another equally important provision is the governor seen to the left of our engraving. It consists of a pressure chamber and piston, which is connected to the discharge side of the pump, and is connected to the balanced throttle valve which supplies steam to the turbine in accordance with the load on the pump. The makers inform us that the set is self-regulating under all ordinary changes, either of the steam or the water conditions.

At the extreme left-hand end of the unit will be seen the emergency governor gear. It consists of an unbalanced ring mounted on the shaft and held in position by a helical spring. When the predetermined maximum speed has been attained, the spring is overcome by the centrifugal action of the ring. When the ring is thus thrown out radially and is in its extreme excentric position, it engages a trigger and through a rod connection it closes the stop valve. By this means the set cannot run at excess speeds, even should an accidental failure of the water supply take place. We understand that the pump ran very quietly at full load, both on test and subsequently in service, and that it can be started up without any preliminary heating.

As there is no oily residue in the exhaust steam which is discharged from the turbine, the firm has supplied a "Weir" type multi-jet heater, which is fitted on the feed tank. The thermal efficiency of the set, which is usually quite low for such small turbines, is raised by this means to a high figure comparable, we learn, with that of an electrically driven pumping set designed for a similar duty.

HIGH-PRESSURE TURBINE-DRIVEN FEED PUMP

G. AND J. WEIR, LTD., CATHCART, GLASGOW, ENGINEERS



Canadian Engineering News.

(From our own Correspondent.)

Canadian Newsprint Production.

The immense production of newsprint achieved by Canada last year not only placed the Dominion far beyond the nearest competitor in that field, but set up a new output record greatly in excess of that ever before attained by any country. The total amount of newsprint paper produced in 1927 in Canada was no less than 2,087,000 tons, the nearest approach to which figure was Canada's own previous record of 1,882,000 tons in 1926, and the United States figure of 1,684,000 tons in the same year. Production in the United States, however, fell off by 201,000 tons, thus greatly widening the gap between the two leading newsprint producing countries and giving Canada a lead of 40·4 per cent. over her nearest rival.

Statistics as to the world production of newsprint recently issued by the Newsprint Service Bureau of New York, covering the year 1927, show that Canada produced approximately 32·1 per cent. of all the newsprint production in the world in 1927, the total for which is stated to be not far from 6,500,000 tons. In the previous year Canada produced 30·8 per cent. of the world's supply, and in 1925 27 per cent. World production in 1926 and 1925 was estimated by the same authority at 6,100,000 tons and 5,600,000 tons, showing an annual growth in the neighbourhood of half a million tons, of which Canada is supplying the lion's share.

In the export field Canada outrivals all other competitors, not only individually but collectively. Of total exports of 3,035,000 tons of newsprint in 1927 attributed to sixteen exporting countries, Canada supplied 1,882,000 tons, or 62 per cent. In the previous year the percentage was 60·2 per cent., total exports for that year being 2,880,000 tons and Canada's share 1,732,000 tons. While Canada leads the world in the export of newsprint, the United States is practically as far in the lead in consumption of this commodity with an apparent consumption in 1927 of 3,460,000 tons, or approximately 53 per cent. of the entire world production. This represents a slight decrease from the previous year when the same authority gave the amount of newsprint available for home consumption in the United States as 3,520,000 tons, or 57·5 per cent. of the world's supply.

Though consumption of newsprint may possibly have dropped off slightly in the United States in 1927, production dropped by a very much greater amount, and to fill the gap the United States imported 1,986,000 tons, compared with 1,852,000 tons in 1926, an increase of 134,000 tons. The United States only produced 43 per cent. of its newsprint requirements in 1927, compared with 48 per cent. in 1926 and 52 per cent. in 1925. This decreasing ability of the neighbouring Republic to meet its own requirements is the principal basis for the continued expansion in the newsprint industry in Canada. So far as Canada's own requirements are concerned, they are relatively small, though growing rapidly. The amount shown as available for home consumption last year was 205,000 tons, which works out at an amount per capita second only to that of the United States.

Persistent reports that a plant would be built to manufacture insulating board from by-product material to be furnished by the newsprint mills of St. Maurice Valley Corporation are confirmed in the announcement that a new company, to be known as National Forest Products, Ltd., is to be brought into existence by and will be jointly and equally owned by Building Products, Ltd., and the St. Maurice Valley Corporation.

Announcement of the formation of the new company came from Mr. P. R. Allen, president of Building Products, Ltd., following the annual meeting of that company. The St. Maurice Valley Corporation will supply the raw material for making "Insul Board" and other similar products, while Building Products, Ltd., will market the board for the new company.

Purchase of a Power Plant and a Paper Mill.

The assets of the Newfoundland Power and Paper Company, Ltd., have been purchased by the International Power and Paper Company, of Newfoundland, Limited, a subsidiary of the International Paper Company. The properties include a 400-ton per day newsprint paper mill at Corner Brook, on the Western Coast of Newfoundland, a hydro-electric power plant generating 98,000 continuous horse-power, and 2802 square miles of timber lands. The controlling interest in the Newfoundland Power and Paper Company was owned by English interests.

A Water Power Project.

The great water power project at Chute à Caron, on the Saguenay River, Province of Quebec, where 800,000

horse-power is to be developed, has grown to such proportions that plans have been prepared for the establishment of a model town in the immediate vicinity to provide accommodation for the thousands of workers. Application is being made to the Quebec Legislature for the necessary charter. The incorporators are the Alcoa Power Company, subsidiary of the Aluminium Company of America, which is carrying out the development, on which extensive works have already been executed, such as the building of a railroad bridge across the Saguenay River below Chute a Caron Falls, and the laying of a railway.

CHAIR OF HIGHWAY ENGINEERING.

WE are informed by the secretary of the Institution of Municipal and County Engineers that arrangements have been made to establish a Chair of Highway Engineering at the City and Guilds (Engineering) College, which forms the engineering section of the Imperial College of Science and Technology for a minimum period of five years. This choice has been guided by the following facts:—(1) The City and Guilds Engineering College has an exceedingly well-equipped building with room for the inclusion of a Highway Engineering Department. (2) It is situated in the Capital of the British Empire; the most appropriate position in view of the fact that students will be attracted from all parts of the Empire.

The Professor will be appointed as soon as possible, and work will begin with the new session in October.

It has been estimated that the interest on a sum of £30,000 will suffice for establishing the Chair in perpetuity having regard to the existing equipment and buildings which can be utilised. Part of the sum required has already been raised by subscriptions and the surplus remaining from the funds of the recent Public Works, Roads and Transport Congress has been devoted to the same purpose. There remains, however, a sum of about £15,000 still to be found. As the benefit of the better education of the highway engineers of the future will accrue to the highway authorities, it is hoped that every highway authority will forward a contribution from its funds. There will be no difficulty in obtaining the sanction of the Ministry of Health for that expenditure.

Many local authorities have already subscribed, and the Institution is so impressed with the need for and the great benefit to the public of such a Chair that it is subscribing £1000 from its own funds.

HYDRO-ELECTRIC POWER IN SWEDEN.

AT a recent meeting of Svenska Vattenkraft-foereningen a paper was read on the development of the production of hydro-electric power in Sweden during 1927. The total production for the year was 4,350,000,000 kWh, and it indicated that the steady increase which had taken place during the past few years continued during 1927. The Government-owned power plant at Norrforsen (North Sweden), which started production in the autumn of 1926, contributed an increase of 82,000,000 kWh; at the central group of Government-owned power plants—the Aelvkarleby, Goeta River, Motala and Vaesteraas works—the increase amounted to 80,000,000 kWh; Sydsvenska Kraftaktiebolaget—a private combine controlling the production of power in the extreme south of Sweden—produced 335,000,000 kWh, compared with 285,000,000 in 1926; Yngeredsfors Kraftaktiebolag produced 56,000,000 kWh, compared with 46,000,000; and the Gullspaang-Oerebro combine 114,000,000 kWh, compared with 87,000,000. The town of Stockholm increased its production by 15,000,000 kWh and a considerable increase is noted at the powgr stations owned by the large industries in Central Sweden.

For 1928 no such big increase as in 1927 is expected owing to the labour disputes, which have reduced the power requirements of several industries; lower water levels are also expected than in 1927.

The total water power exploited in the country at the beginning of the year was 1,475,000 horse-power; the increase during 1927 was only 20,000 horse-power. This year the Hammarforsen power station—27,000 horse-power—has been completed, the Kraangfors power station—17,000 horse-power—is expected to start in a few months, and additional plant of 18,000 horse-power will be completed this year at the big Porjus power station in northernmost Sweden. The Munkfors station on the Klar River—Vaermland—and the Ianforsen station on the Dal River will not be ready to start until 1930. The Sydsvenska Kraftaktiebolaget has begun the construction of a 40,000 horse-power plant at Karseforsen on the Lagan River—for which purpose a loan of Kr. 11,000,000 is to be issued—and plans have been prepared for the exploitation of the Avesta-Storfors rapids on the Dal River and the Askesta and Hoeljebro rapids, owned by Bervik och Ala Aktiebolag, on the river Ljusnan. The rapidity of the development of power production in the Central Swedish industrial district—Bergslagen and the neighbouring regions—has been particularly remarkable and has resulted in an increase in power production of 50 per cent. in five years; further expansions are expected.

THE iron ore mined in the United States in 1927 amounted to 61,741,100 gross tons, a decrease of about 9 per cent. as compared with 1926. Compared with the average for the preceding five years, however, the production in 1927 is greater by about 3 per cent. Operations in the north-eastern States were on an increased scale in 1927, especially in New York and Pennsylvania, in which increases of 34 and 7 per cent. respectively were recorded, and there was an increase of 6 per cent. in New Jersey. More ore was mined also in North Carolina, Virginia, and Montana in 1927 than in 1926, but in all the other iron ore producing States mining was on a reduced scale.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

General Conditions.

WHILE the general outlook in the Midlands area continues more favourable than it was, it appears that this improvement is more due to the prevalence of stringent conditions on the Continent than to any reinvigoration of consumptive demand. Increased business is undoubtedly coming to local mills, but there is small evidence that manufacturers' order books are becoming more bulky. They are, however, using native raw material in place of foreign, which is all to the good. In the heavy industries the position shows little change on the week, but there is an indication that the trend is in an upward direction. General engineers are active, and constructional engineers are anticipating better business. The nut and bolt works and tube makers are fairly well placed for orders, the former finding some good export business, and this is bringing more steel orders to Black Country mills. The tube trade is subject to keen competition. Neither ironmasters, steel masters nor engineers can see very far ahead, and buying continues of a hand-to-mouth character. Values tend to become firmer, but consumers hesitate to commit themselves forward even under these circumstances. There is, however, some speculative buying in several departments of the market by Birmingham merchants.

Pig Iron.

The weakest department of the Birmingham market is that of pig iron. This raw material is almost unsaleable, although makers complain that the prices quoted carry no profit. It is extremely difficult to arrive at market values, for while some smelters adhere to recent quotations but accept "cut" rates for substantial tonnages, others, who are forced to reduce their stocks, do so on special agreed terms, which vary in almost every case. What their minimum is, it is practically impossible to discover. One thing is certain, foundry iron is to-day being sold in the Midlands at rates which entail an actual loss to the producer. Most consumers are eager to avail themselves of the opportunity to buy on such terms, but their present requirements are small, and many of them act with considerable caution. Some users have decided that the wisest course is to await developments, while others, more venturesome, refuse to buy heavily and are content to purchase sufficient for estimated requirements over the next month or two. There is a good deal of talk amongst blast-furnacemen of further curtailments of production. The prices quoted on 'Change in Birmingham to-day—Thursday—for pig iron were:—Derbyshire No. 3 foundry, £3 2s. 6d. to £3 3s.; forge, £2 18s. Northamptonshire foundry, £2 17s. to £2 17s. 6d.; forge, £2 13s. 6d. As pointed out above, however, these figures were only taken as a basis for negotiation and did not represent the actual prices at which business was transacted.

Manufactured Iron.

The Staffordshire iron trade maintains its slightly improved activity. Best iron is in very fair demand for shipbuilding and engineering requirements, and £12 per ton is readily paid for marked bars. The difference between quotations for Crown bars continues, ranging from £9 5s. to £10 5s. Staffordshire makers state that they have received a little more business of late, and are hoping for an improved proportion of the available work in the near future. Little is heard just now of Belgian No. 4 iron. Staffordshire ironmasters who turn out Crown bars are faring rather better. No. 3 Belgian iron is practically off this market for the present, £6 15s. no longer being attractive to the Black Country nut and bolt trade. The local forges have supplied more iron to the nut and bolt works than for a long time past. Big contracts placed with the Continent during the last year or two are no longer a feature. Local nut and bolt bars are still named £8 17s. 6d. to £9 per ton. The call for wrought iron gas tube strip has not revived, but makers have a fair reserve of orders, and values are unchanged at £11 per ton.

Steel.

In the steel department business continues to grow. The demand upon the Midland mills at date is chiefly for structural steel and for carriage and wagon building, both of which still absorb good quantities. Several of the local industries are taking better tonnages from the Black Country. Values of finished material show no sign of change so that forward buying is rarely indulged in. It is not so easy as it was to get immediate deliveries, but there is no delay in executing orders promptly. Advices from the Continent are to the effect that foreign prices are unlikely to fall, and consequently many engineers have placed orders for large tonnages of iron and steel with British mills. The outlook for the steel works is, as a result, very much brighter. The position with regard to billets and other semi-finished material has completely changed. Not long ago they could be bought at £1 at least per ton below Welsh billets, but the foreign material now costs £5 15s., whether billets or sheet bars. The great advance has enabled makers at home to raise their prices, and values now range from £5 17s. 6d. to £6. Wire rods, which a few months ago were bought from abroad, are now obtained at the same price from native mills, while steel strip, of which large quantities are used by tube works in this district, can be bought from home mills for something like 10s. per ton less than German material.

Galvanised Sheets.

Galvanised sheets are firm at the increased price of £13 5s. to £13 7s. 6d., but the business on offer is nothing like sufficient to keep the mills fully employed. While orders are difficult to get, manufacturers hold that there is a lull in consumptive demand, which is independent of price.

Tin-plates.

Sales of tin-plates in the Birmingham area have not undergone any noticeable development this week. The tin-plate branch is well placed, and most of the mill capacity lately employed is assured of steady occupation over the next month or two. The delivery dates which apply to new commitments range from the latter end of July to September. Output, it is reported, is being further increased.

Ironworkers' Wages.

The recent fall in values of iron and steel are reflected in the bi-monthly ascertainment under the Midland Iron and Steel Wages Board. The decline has been such as to cause ironworkers' wages, which are regulated by a sliding scale, to be reduced by 2½ per cent. From date until August 4th wages will be calculated at 30 per cent. above the puddling base rate of 13s. 6d. Twelve months ago the percentage stood at 52½.

Cannock Chase Coal Deficit.

There was a loss of 6·15d. per ton on all coal produced in April, in the Cannock Chase and Pelsal coalfield, which was 1d. per ton more than in the previous month. The total accumulated deficit is now £1,703,805. Wages of miners in this coalfield for June will be the same as for the past ten months, 42 per cent. on the 1911 wage basis. The actual capacity of the industry to pay, however, based on the costs of production, selling prices, &c., for February, March and April, is only 14·57 per cent., the difference between this figure and the 42 per cent. having to be met by the coalowners.

Weak Canal Bridges.

Considerable attention continues to be given in this area to the necessity of strengthening weak canal bridges. Details of the position have previously been given in my weekly letters. The Railway and Transport Committee of the Birmingham Chamber of Commerce in its report to the Council this week stated that it realised the task of the local authorities in arranging a scheme for the permanent strengthening of weak canal bridges was a very onerous one, beset with considerable difficulties. The canal authorities unfortunately had not shown the interest in the problem which traders might have desired, but had merely adopted the attitude of non-responsibility on the ground that their full legal obligations had been and were being complied with. In the meantime, the difficulties of the trader were being multiplied, owing to the weight restrictions prescribed for canal bridges in various parts of the district, including those on main roads.

Coventry's New Sewage Scheme.

Coventry's new sewerage and sewage disposal scheme, which is estimated to cost £226,000, was considered by the City Council on Tuesday when the Sewage Disposal Committee recommended that application should be made to the Ministry of Health for sanction to a loan for the sum mentioned. The scheme involves an extension of the city's main outfall sewer from Whitley to Finham, and the construction of new sewage disposal works on a site near Finham Bridge. The cost of the sewer from Whitney to Finham is estimated at £70,000. Near the Finham golf links a length of sewer will be constructed in a tunnel at a maximum depth of 50ft. The scheme is designed to meet the city's requirements for the next sixty or seventy years.

Unemployment.

The holidays are responsible for the large increase in the unemployment figures for the Midlands area, and a considerable improvement is anticipated in the next returns. The report for the week ended May 29th showed the number of persons registered as unemployed to be 208,642, as compared with 151,911 for the previous week. To the total the Birmingham area subscribed 25,571 and the Stoke-on-Trent area 21,620.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Electricity Profits.

SATISFACTORY results have attended the year's operations of both the Manchester and the Salford electricity undertakings. In the case of the Manchester Corporation Electricity Department a decline in income from the sales of current to £1,604,167, compared with £1,643,137 in the previous year, has been more than counterbalanced by a reduction in working expenses from £984,106 to £864,417. This resulted in a balance for the past year of £739,750, compared with £659,031, or a net surplus after allowing for debt and tax charges of £110,942, against £40,659 in the previous year. The Committee reports an addition of about 90 miles to the mains laid, making a total mileage of more than 900. For the twelve months ending March 31st last the work of the Salford Electricity undertaking resulted in a record net profit of £65,137, against £12,000 in the previous year, when, however, the department was involved in an extra expenditure on coal as a result of the mining dispute of about £40,000. The chairman of the Electricity Committee states that the progress of the undertaking since the opening of the Agecroft power station in 1924 has amply justified the expectation that the extension scheme, which cost in the neighbourhood of £750,000, would be a sound investment. Since 1924 the consumption of current in the area served by the Salford undertaking has increased from 38,746,444 units to 60,696,656 units last year. In the same period four reductions in charges to consumers have been made, these amounting, in the aggregate, to a reduction of 33½ per cent. in the average price per unit.

Storing Steam.

An order for three Ruths steam accumulators, to work in conjunction with the existing high-pressure boiler plant, has been placed by Taylor Brothers and Co., Ltd., of Trafford Park, Manchester.

Non-ferrous Metals.

With the exception of tin, which has now touched a new low record for this year, the other sections of the non-ferrous metals market have maintained a steady to firm tone, lead being conspicuous by a further important advance on the week. On balance there is little change to report in the price position with regard to copper. Both standard brands and refined descriptions of the metal have been well held at the recent advance, and the indications point to continued steadiness being registered in this section of the market. Taking a wide view of the situation, the current demand for copper seems to be more than adequate to take care of the supply at the present rate of production, and the market appears to be expecting a further improvement in the statistical position when the figures relating to American refinery stocks at the end of May are available. Warehouse stocks of the metal in this country show a moderate decline compared with the end of April. With tin supplies increasing the immediate outlook in this section, judging from the movements of prices since last report, would seem to favour the "bears." The decline up to the close of the market last week-end had been relatively slight, but on the opening days of the present week a steady fall brought prices on balance to more than £4 a ton below the parity of a week ago. Following the advance reported last week lead has acquired added strength as a result of sustained buying from many directions, current values of the metal being about the highest recorded this year. There has been no special feature about spelter, but with a moderate volume of inquiry about quotations have kept fairly steady.

Iron.

Whilst there has naturally been a better movement of pig iron on this market during the past week compared with the inactive conditions that have been ruling as a result of the Whitsun holidays, conditions at the time of writing are by no means as satisfactory as they were before the holiday break, relatively poor as has been the demand for foundry iron during the past month or so. There is still a disappointing absence of interest among consumers of pig iron with regard to contract buying. This is due probably partly to the fact that users are not yet convinced that the fall in prices has definitely come to an end, and partly also because foundry order books in many instances are not so favourably situated as to justify buying forward on any appreciable scale. There has, however, been no further weakness in Midland foundry irons, which command the biggest sale on this market. Derbyshire brands are currently quoted at from about 70s. 6d. to 71s. per ton, delivered Manchester or equal, with Staffordshire at about the same range. Middlesbrough No. 3 keeps steady at 79s., Scotch at from 87s. 6d. to 90s., and hematite at 83s. 6d. per ton, all delivered. A quiet trade is being done in bar iron, and here again sellers are able only to book orders for near delivery dates. Lancashire Association prices, however, are unaltered, Crown quality bars being quoted at £10 per ton and seconds at £9 10s.

Steel.

In the conspicuous absence of forward buying, conditions in the steel market are very similar to those mentioned in the case of pig iron. An essential difference is that steel prices generally appear to be quite steady, but whilst buyers have thus little to fear from a falling market, they see nothing to be gained by covering themselves forward under present price conditions, particularly as there is practically no difficulty in securing what amounts to almost immediate delivery. A moderate demand is reported from the constructional engineering trade, and a number of orders for boiler plates, mainly from the locomotive shops, have been booked. Frame and general plates are quoted here at £8 12s. 6d. per ton; boiler plates at £9 15s. to £10; joists at £7 17s. 6d.; small re-rolled bars at from £7 12s. 6d. to £7 15s.; and large bars at £8 17s. 6d. In many respects imported steel materials have further advanced, bars and angles being quoted at £6 17s. 6d. per ton; wire rods, £6 15s.; Siemens plates at £8 2s. 6d. to £8 5s.; joists at £6 2s. 6d.; sheet bars at £5 15s.; and billets at £5 12s. 6d. for net cash against shipping documents, and including delivery to works in the Lancashire district.

BARROW-IN-FURNESS.

Hematite.

There is nothing new to report in the hematite pig iron trade. The output from the eleven furnaces in blast is not all being absorbed by customers, and there is a certain amount going into stock. At present there are no signs of any improvement in the state of the market. The Midlands continue to be the biggest customers. If the steel departments were engaged a fair amount of iron would be taken by them, but practically the whole of them are idle, at any rate those which take any great tonnage. American business is dull, and the continental trade does not show much life. The iron ore trade continues to be moderate, and there is not a large tonnage going out of the district. Foreign ore is being bought in moderate quantity. The steel trade does not show much life. A few orders are held for railway material, but the total up to the present does not justify a restart being made with the mills. The hoop mills are the only mills running at Barrow, and they as usual are experiencing a steady run, with sound prospects for the future.

Shipbuilding.

The Orient liner "Oronsay" is undergoing overhaul, and may be detained here for a short period. Another submarine of the "O" class will be launched by Vickers, Armstrongs this month, and a sister ship, making the third launched this year, will come off the stocks in August. The big Admiralty tender "Medway" is being pushed on well, and will be launched next month. The Orient liner on the stocks is beginning to grow, but her launching date is not yet announced.

SHEFFIELD.

(From our own Correspondent.)

A Period of Quietude.

ALTHOUGH the situation on the Continent continues such as to promise benefit to the British steel trade, those branches which are carried on in this locality are passing through a time of quietude. The resumption after the holidays found many departments short of work, especially on the heavy, open-hearth side. The falling off in the receipt of orders and inquiries since the beginning of May has necessitated a considerable reduction of production, and the number of furnaces in operation at the moment is the smallest since the coal stoppage. At the same time, some kinds of mild steel can now be bought as cheaply at home as on the Continent, and, as there does not appear to be any likelihood of foreign prices falling, the tendency to place business in this country should grow during the year. There is increased activity in the scrap market, which indicates that steel makers are expecting a larger demand for their products shortly.

The Lighter Branches.

The lighter departments of the steel trade are in little better case. The briskest sections are those which deal with specialities. The electrical engineering industry is busy, and is a large customer for small and medium castings, and other Sheffield products. There is still a good demand for special steel and parts for the motor car, motor-cycle, and cycle trades. Stainless steel continues to progress, and the uses to which it is put is legion. In ordinary lines, however, the position is not satisfactory. Since the early part of the year there has been a considerable falling off in the sales of tool steel and engineers' tools. Slackness is reported at the iron foundries, which are competing keenly for the reduced trade in stove grates and other builders' ironwork.

Cutlery and Plate.

The holiday at the cutlery and plate works was somewhat prolonged, and the reopening this week was not on a full-time scale. Firms holding contracts for the equipment of steamships and restaurants are doing well, and in addition to this work fairly substantial special orders continue to be placed in the city, but the general trade, through ordinary shopkeeping channels, is flat. In cutlery, the scissors branch is an exception to the prevailing state of things, as it shows a marked improvement. There has been a continuous increase in sales, both at home and abroad, during the past five months. The value of the safety razor trade to this country is shown by the February returns. During that month we exported to the United States of America alone 800,000 dozens of razors, blades and blanks, while our imports from the States consisted of 553,351 dozens of blades. The exports were valued at £10,000. It is understood that all the Gillette blades supplied to England are made from blanks produced by a Sheffield steel firm.

Some Contracts.

The Metropolitan Railway Company, which is building flats at Baker-street Station, has placed a contract for large girders with Messrs. Markham and Co., Broad Oaks Works, Chesterfield. The weight of the girders ranges from 15 to 58 tons. One was dispatched recently which was 66ft. long, with a depth of 4ft. in the centre, and was composed of five webs. The Markets Committee of Sheffield Corporation is building a large abattoir and recommends acceptance of the following tenders for equipment, &c.:—The North British Lifting and Moving Appliance Company, Ltd., equipment, £10,481 15s. 10d.; Hughes and Lancaster, Ltd., paunch manure plant, £1808; R. and W. Hawthorn, Leslie and Co., fireless locomotive, £1533 10s. 3d.; Brightside Foundry and Engineering Company, Ltd., laundry plant, £558. Another tender recommended for acceptance is that of Mr. W. G. Robson, amounting to £16,205, for the erection of two new wards and a portion of the isolation block, at Lodge Moor Hospital, to provide accommodation for fifty-eight beds.

Coal in Lincolnshire.

The prospects of the extension of colliery enterprise in Lincolnshire are continually growing. The great coalfield of which Doncaster is the centre continues into the north-eastern portion of the adjoining county, and for some time explorations have been taking place on the edge of Hatfield Chase, once a wilderness of peat bogs until reclaimed in the time of Charles I. by the Dutch engineer Vermuyden. A bore-hole has been sunk at Lindholme, in the centre of the Hatfield moors. The work has been finished some time, and it is known that coal was found, but there is little further information as to the results. More recent developments have been borings at Sandtoft, about seven miles east of Hatfield, where it is reported that a depth of 1000 yards has now been reached. Sandtoft stands at a spot where five roads meet, and a single line railway, connected with the London, Midland and Scottish system at Epworth, is less than a mile distant.

A Successful Water Boring.

For some time there has been need of a further water supply for Thorne, one of the growing places in the Doncaster coal area. As recently as eight years ago, one working day of eight hours, pumping 15,000 gallons per hour, yielded a sufficient supply to last the district a week, but now 30,000 gallons an hour has to be pumped for twenty hours a day and on seven days in the week. Work on a new 2ft. bore-hole has been in progress for six months, and water has now been tapped at a depth of 450ft. The supply has been tested, and, for some hours continuously, 45,000 gallons per hour have been pumped. It is intended to install a new electric pump almost immediately to work the new supply, and to retain the old water for emergency purposes.

Sheffield Waterworks.

Sheffield Corporation continues to report good progress with the construction of the great new waterworks in the Ewden Valley, a few miles away from the city, on which it is has been engaged for several years. During the twelve months ending March last, all sections of the work have been advanced. The average number of men employed was 462, and the expenditure £217,394, making up a total, to date, of £1,491,584. The laying of twelve miles of 36in. and 30in. diameter mains for conveying the water to the Wadsley and Moonshine service reservoirs, and forward to the city, is well in hand, and will provide work for about 400 men for twelve months.

A Large Electrical Scheme.

Electrical extensions on an exceptionally large scale are to be carried out by the Corporation of Bradford, to meet the increasing demand for current, and the works have been formally started this week by the laying of foundation stones. A new set of 30,000-kilowatt capacity is to be installed, at a cost of £250,000.

NORTH OF ENGLAND.

(From our own Correspondent.)

Iron and Steel Trade Disappointment.

ANTICIPATIONS of a marked revival in the Cleveland iron and steel trade which were entertained at the beginning of the year have not materialised, and the five completed months provide a disappointing record. The number of blast-furnaces operating has been further reduced, the output of both pig iron and steel has steadily dwindled, and there has been an almost continuous decline in the volume of the foreign trade. At the beginning of the year there were forty blast-furnaces in operation on the North-East Coast. There are now only thirty-seven working throughout the district, which represents only half the normal number operating in pre-war days. The position with regard to the export trade is very discouraging. Since February, when 85,281 tons were shipped, there has been a steady decline, and the May total was no more than 71,252 tons, of which 16,351 tons were pig iron and 50,901 tons manufactured iron and steel. Both these figures are the smallest for any month of 1928. The foreign shipment of pig iron in May fell short of the April total by only 150 tons, but there was a drop of nearly 4000 tons in the coastwise shipments, both Wales and Scotland taking substantially reduced quantities. In April there was shipped rather more than 4000 tons of pig iron to France, Belgium and Germany, whereas in May the total shipment to these three countries amounted to no more than 358 tons. Manufactured iron and steel exports declined from 61,374 tons in April to 54,901 tons in May. There was, in fact, a general decline in the exports to nearly all destinations, Australia and New Zealand, with a total of 6844 tons, alone taking increased quantities. To West and East Africa about 2000 tons less material was shipped in May than in April. The drop in the Indian trade approximated 4000 tons, and there was a similar decline in the shipments to South America.

Iron and Steel Imports.

It is satisfactory to record that imports of iron and steel from foreign destinations to the river Tees continue to dwindle. Statistics presented at this week's meeting of the Tees Conservancy Commission showed that during the past seven months 134,145 tons were brought into the river, as compared with 248,589 tons in the corresponding period of 1926–27, and 42,718 tons in the pre-war period of 1913–14. The outstanding feature in connection with the returns is the fact that only 4408 tons of pig iron were imported during the seven months, as compared with 80,944 tons in 1926–27, and 181 tons in 1913–14, thus indicating that Cleveland iron producers are at last meeting foreign competition in the pig iron trade. Plates, bars, angles, rails, sheets, joists, &c., unloaded during the past seven months totalled 26,770 tons, as compared with 35,522 tons in 1926–27, and 15,124 tons in 1913–14. The imports of crude sheet bars, billets, blooms, slabs, &c., amounted to 102,967 tons, compared with 132,123 tons in 1926–27, and 27,413 tons in 1913–14.

Cleveland Iron Trade.

The Cleveland pig iron trade is without any special feature this week. Stocks are about as low as is convenient to makers, and as current needs are not quite covered by production, the small quantities held at the works are likely to be further reduced, unless the make is increased. Most of the output is still going into direct use at ironmasters' own works. Deliveries to home consumers in other areas are not heavy, and dispatches to customers beyond the Tweed show some falling off, while loadings for shipment overseas keep light. Buyers are, if anything, slightly less hesitant than of late, but they are as disinclined as ever to commit themselves at all extensively for forward supplies. Makers adhere to their fixed quotations. No. 1 Cleveland foundry iron is 68s. 6d.; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; and No. 4 forge, 64s. 6d.

Hematite Pig Iron.

East Coast hematite is becoming more plentiful, and orders are obtained only by accepting terms substantially below cost. Prices are not definitely fixed, and rates at which contracts are made vary considerably. Stocks are rather heavy, and one or two furnaces may be put out of blast if demand does not speedily expand. Nominally, quotations are still based on mixed numbers at 70s.

Ironmaking Materials.

The foreign ore trade continues dull and featureless. Merchants keep prices on the level of 22s. 6d. per ton c.i.f. Tees for best Rubio, but consumers are not in the market, as they consider these terms too high. Sellers, however, in view of probable shortage, think values are more likely to advance than otherwise. Coke is a little firmer, due to export sales. Good blast-furnace sorts are 17s. 6d. to 17s. 9d. per ton delivered at the works in this district.

Manufactured Iron and Steel.

Business in manufactured iron and steel rules on quiet lines, and in some departments manufacturers are getting short of work. There seems little prospect of a gathering momentum from shipyards, and railway demands are below expectations. Distribution of specifications for constructional work is also disappointing, but it is understood that big bridge-building and electrical projects are pending, which may provide work for this district. A further advance has been made in sheets, black sheets being now quoted at £10, and galvanised corrugated sheets, 24 gauge, £13 5s. to £13 10s.

The Coal Trade.

Although holiday interruptions will limit outputs towards the end of the month in Durham and Northumberland, there is no particular anxiety on the part of buyers to secure supplies. The market shows a quietly steady prompt trade, with, however, no expansion in sight. Inquiries are of a very fair volume, but buyers are reluctant to book beyond their early needs, seeing that they have under consideration offers of cheaper coal from other centres in this country and abroad. Tenders have been invited lately for the supply of large quantities of fuel, and results are keenly awaited. The adherence of Northumberland producers to the "fixed" prices does not encourage shippers to speculate, and there is some trepidation over the outcome of this business. For the time being the majority of the collieries in Northumberland and Durham are working fairly regularly on prompt orders, and the business previously placed with them, and there should be no trouble in loading arrangements, for there is a plentiful supply of tonnage, and freights, in the main, are low. Direct, best Northumberland steams are steadily marked at 13s. 6d., and second-hand dealers are not prepared to sell at much less than a copper or two below that price. There is a surplus of smalls, which are at anything from 8s. to 10s., according to brand. The secondary grades of fuel are in chief demand from gas coal users, bests and specials being in want of additional trade. Both coking coal and bunkers are moving off well, but not in sufficient quantities to meet output. Gas coke is quiet for immediate delivery at 20s., but forward, up to 22s. is asked under a broadening demand. In the same way, patent foundry is stronger and dearer for later positions. Shippers maintain a steady export trade in blast-furnace coke, which does not improve in the home trade.

Coal Miners' Wages.

The position of the coal-mining industry of Durham and Northumberland shows no sign of improvement; indeed, it is getting worse. If there was not the protection of a minimum percentage the wages of miners in Northumberland during this month would be actually less than the basis by 2·85 per cent. This is indicated by the joint report of the accountants on the proceeds and costs of the industry in April. In May the percentage was 5·66 per cent. on the basis, and, therefore, with the percentage of 2·85 below the basis, there is a fall on the month of 8·51 per cent. The owners are thus faced with a deficiency of 42·85 per cent., as the minimum percentage on the basis is 40. Under present conditions, the economic state of the industry is probably without parallel in the modern history of the country. The ascertainment for Durham shows that but for the minimum percentage wages would be 25·18 per cent. above basis rates, as against 28·82 in May, a reduction of 3·64 per cent. The minimum percentage addition to basis wages in the county is 65, and therefore the deficiency to be made up by the owners this month will be 39·82 per cent.

Ironworkers' Wages Reduced.

As the result of a fall of 7s. 2d. per ton in the average net selling price of manufactured iron, the wages of puddlers and other forge and mill workers employed in the North of England manufactured iron trade have been reduced by 5 per cent.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding.

THE output from Clyde shipyards during May, amounting to twenty-eight vessels of 49,461 tons aggregate, is well up to the average for that particular month. The output for this year to date, amounting to eighty-seven vessels of 240,732 tons aggregate, is the largest since 1925, and 53,265 tons short of the maximum recorded during the period. A number of good orders were reported during May, but with work proceeding smoothly at the yards the rate of output is still in excess of contracts booked. Everything possible is being done to reduce costs by the acceleration of outputs, but the state of the freight market continues to react against the shipbuilding industry, shipowners having as yet little confidence in the immediate future of ocean traffic. During May eight steamers of over 4000 tons each were launched, six of them being cargo steamers and one an oil tanker. The largest ship launched was the twin-screw motor ship "Karamea," 8650 tons, built for the Shaw, Savill and Albion Company, Ltd., London. Contracts reported included two twin-screw motor liners of 15,000 tons each for the Prince Line, Ltd., London, a passenger and cargo steamer for the Compagnie Française des Phosphates de l'Oceanie, and a motor dredger to cost £12,000 for the Otago Harbour Board, New Zealand.

Steel.

Conditions for the most part remain dull. With very few exceptions plants are irregularly occupied, and there is little prospect of an early improvement. Fair orders for steel rails have been received from abroad, but home steel makers would welcome an increase in the demand for shipbuilding material. Consumers who are independent of continental raw materials are taking some encouragement from the firmer tone of prices abroad, but apart from this there seems little cause for satisfaction.

Steel Sheets.

The sheet trade is rather disappointing. Heavy black sheets are particularly slow, while galvanised descriptions are quieter than usual.

Iron.

Bar iron makers are poorly placed in respect of new business. Fair export orders for strips and hoops have been put through, but home demands are very small. Business in steel bars re-rolled from foreign billets is far from excessive. Bar iron prices are unchanged and re-rolled steel quotations also show no change so far, though the latter are now "free." Pig iron is more or less inactive.

Exports and Imports.

During the past week 6400 tons of iron ore, 1000 tons of chrome ore, and 1400 tons of steel and iron products were discharged at Glasgow Harbour. Shipments of iron and steel amounted to 7000 tons, despatched chiefly to the Colonies, Spain and South America, England and Ireland.

Coal.

Notwithstanding the efforts of the colliery owners to stabilise the market by drastic reductions in output, only a very moderate measure of success has attended their efforts. It is now proposed to extend the scheme to accomplish a reduction in outputs beyond the original estimate of 100,000 tons per week, and collieries are now being asked to co-operate in a further effort to reduce outputs by 150,000 tons per week. Meanwhile, the shipping demand shows no signs of expansion, exporters being only inclined to purchase small lots against immediate requirements. Lanarkshire splints are well booked for a few weeks ahead, and ells are also well placed owing to reduced outputs. Fifeshire steams are firm, but Lothians steams are not too well placed. Washed materials are irregular. Aggregate shipments amounted to 236,660 tons, against 272,268 tons in the preceding week, and 252,490 tons in the same week last year. Home demands decrease as the season advances.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

THE conditions in the steam coal trade are very disappointing, inasmuch as following upon the holidays new business appears to be more scarce than ever. The tone all round is extremely quiet, though the collieries are for the time being comparatively well placed, as the result of tonnage coming along, which was chartered prior to the vacation. On Tuesday there were only twenty-two idle loading appliances at the various docks, which is lower than usual, but it is difficult to say how long that state of things will last, as chartering during the past ten days has been on a reduced scale, and fresh orders are slow to come along. Last week, owing to the holidays, shipments were very adversely affected, the quantity being only just over 342,000 tons, as against nearly 416,000 tons the previous week. The returns for the whole of May are likely to make a very poor showing, and be little, if any, better than those for April. There are certainly inquiries going round for supplies of coal, but it is doubtful whether the business will come to this district. A case in point is the inquiry on behalf of the Belgian State Railways for about 100,000 tons of various qualities of large, small and sized coals. The chances are that the business will be retained for Belgian coals. An order which has usually been placed either for Welsh or Scotch coals is that for the supply of 40,000 tons for the Newfoundland Railways. On this occasion it has gone for special Northumberlands, the price being reported on the basis of 12s. 9d. f.o.b. for shipment from this month to December. A Cardiff firm has secured the order for 15,000 tons of large coal for the Palestine Railways for delivery at Haiffa, and it is understood that a fair amount of business has been done by collieries for Welsh coals for home railways.

Coalfield Losses.

An official statement regarding the report of the joint accountants of the South Wales Conciliation Board for the three months February, March and April last, states that, like all other audits under the present wage agreement, it shows a considerable loss on the working of the industry. The trading position was, on the whole, slightly better than in the preceding three months. The loss shown in the report amounts to £693,438, compared with £761,312 in the three months ended January last, a decrease of £67,874, equal to 1·83d. per ton. This slight improvement was attributable to a larger output and partly to a lower cost of production, as there was a decrease in the wages cost per ton of 4·3d. and in the other costs of 2¼d. per ton. The increase in production was approximately 150,000 tons. Under these conditions the economic wage certified by the accountants is a little higher than in the three months ended January last. It amounts to 8·4 per cent. below the 1915 standard rates, compared with the percentage of 9·71 below those rates certified under the last audit. The miners, however, are guaranteed a minimum percentage of 28 above the 1915 standard rates, and the difference between this and the economic wage of 8·4 per cent. below these rates will have to be found by the collieries. The trading losses for the past fifteen months amount to £2,902,293. The number of persons employed during the quarter ended April was 169,002, which compares with 177,971 during the preceding quarter and with 233,139 in the year 1913.

Traffic Returns.

According to the official returns of traffic at the six docks under the control of the Great Western Railway Company in South Wales, the total of imports and exports for the four weeks ended May 18th came to 2,781,310 tons, which compares with 2,540,438 tons for the preceding month and with 3,131,554 tons for the corresponding period of last year. Taking the whole of this year to May 18th imports and exports came to 7,491,807 tons, as against 8,182,290 tons, so that it will be seen that considerable leeway has to be made up.

Tin-plate and Steel Items.

Welsh tin-plate bars have been advanced in price by 2s. 6d. per ton to £6 delivered South Wales and Monmouthshire. This makes an advance of 5s. per ton in the past month, and is brought about by the increasing strength of heavy steel scrap. This extra 2s. 6d. per ton means about 1¼d. per box increase in the cost of production of tin-plates, which as a consequence are being quoted higher. Arising out of the strike recently of tin-house men at the Gorseinon Tin-plate Works, it is reported that an amicable settlement was arrived at at the end of last week. An inquiry was promised the men into the whole of the circumstances, and this result has been secured without the intervention of the Joint Standing Committee of the Tin-plate Conciliation Board. There was another strike last week on the part of the magnet and charge drivers which caused work at the Upper Forest Steel Works, Morriston, to be suspended and a loss to the company, while the men lost approximately £10,000 in wages. The men, however, agreed to return to work, which meant the restarting of the undertaking on Monday last. The men received an assurance that the question of the revision of tonnage rates should be investigated by a Committee without delay.

Anthracite Collieries Amalgamation.

It is reported that Sir William Berry will go on the Board of the Amalgamated Anthracite Collieries in the place of the late Lord Buckland, in order to represent the interests of the Buckland-Llewellyn group. Another amalgamation of anthracite undertakings has just been completed, according to Mr. T. H. Henderson, the managing director. The undertakings comprise Pwllbach, Tirbach and Brynaman Anthracite Collieries, Ltd., Blaina and Raven Anthracite Collieries, Ltd., Cwmllynfel Anthracite Collieries, Ltd., Garnswllt Anthracite Colliery Company, Ltd. The amalgamation of these concerns has been ratified by the Board of Trade and registered under the new title of Henderson's Welsh Anthracite Collieries, Ltd. The whole of these collieries have recently been equipped with the most modern breaking, screening, sizing and washing plants, and at the present time are capable of producing a million tons per annum, increasing to a million and a-quarter by the end of the present year.

Current Business.

Day-to-day operations in steam coals have been very quiet since the holidays, and very little fresh inquiry is about. The Executive Committee of the South Wales Coal Marketing Association decided at the end of last week to make no change in the minimum prices recently fixed for the various qualities of coal. This was not surprising in view of the lack of improvement in the demand from abroad and of the general conditions prevailing. Leading qualities of coal are fairly steady as they are for the time well placed in the matter of ready tonnage, but dry coals find very little demand, and the same applies to most of the inferior descriptions of large. Small coals maintain a good tone, but patent fuel and coke continue to be featureless.

CONTRACTS.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., has obtained a ten months' contract from the London and North-Eastern Railway for the supply of Mazda vacuum and gas-filled train-lighting lamps.

ROBERT STEPHENSON AND Co., Ltd., of Darlington and 25, Victoria-street, Westminster, S.W. 1, have received a further order from the Crown Agents for two 4–8–0 type non-superheated locomotive engines and tenders for the Tanganyika Railway.

GWYNNES PUMPS, Ltd., of Hammersmith Works, Lincoln, has recently received orders for (*a*) a 48in. centrifugal pump with engine, boilers, &c., for British Guiana; (*b*) three 44in. centrifugal pumps with motors, &c., for Southampton storm water pumping plant; (*c*) two 18in. turbo condensing circulating pumps and gear for Pekin power plant; (*d*) two 16in. turbo condensing circulating pumps and gear for Calcutta power station; (*e*) a gold dredging plant to deal with 100 tons of gravel per hour for Alaska; and (*f*) sewage pumps for Stockport, the Upper Stour Valley Main Sewerage Board, Fleetwood, Sheerness, Swinton and Pendlebury, and Burnley.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Monday afternoon, June 4th, Sir Arthur Keith, Treasurer and Vice-President, in the chair. The special thanks of the members were returned to the Council of the Institution of Electrical Engineers for its gift of a portrait of Faraday after the painting by George Harcourt, R.A. General Sir John Maxwell and Mr. Sydney Walton were elected members.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	19/- to 21/-
(1) Spanish	19/- to 21/-
(1) N. African	19/- to 21/-
N.E. COAST—	
Native	18/- to 21/-
Foreign (c.i.f.)	22/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 14 0	—
No. 1 Foundry	3 15 0 to 3 16 0	—
No. 3 Foundry	3 10 0 to 3 11 0	—
N.E. COAST—		
Hematite Mixed Nos.	3 10 0	3 10 0
No. 1	3 10 6	3 10 6
Cleveland—		
No. 1	3 8 6	3 8 6
Silicious Iron	3 8 6	3 8 6
No. 3 G.M.B.	3 6 0	3 6 0
No. 4 Foundry	3 5 0	3 5 0
No. 4 Forge	3 4 6	3 4 6
Mottled	3 4 0	3 4 0
White	3 4 0	3 4 0
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	—	—
,, ,, Foundry	3 2 6	—
(3) Northampton—		
Foundry No. 3	2 17 0 to 2 17 6	—
Forge	2 13 6	—
(3) Derbyshire—		
No. 3 Foundry	3 2 6 to 3 3 6	—
Forge	2 18 0	—
(3) Lincolnshire—		
No. 3 Foundry	3 2 0	—
No. 4 Forge	3 0 0	—
Basic	3 0 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 2 0 (a) / 4 5 0 (b) / 4 8 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 5 0	—
Common Bars	10 5 0	—
Best Bars	10 15 0	—
LANCS.—		
Crown Bars	10 0 0	—
Second Quality Bars	9 10 0	—
Hoops	13 0 0	—
S. YORKS.—		
Crown Bars	10 10 0	—
Best Bars	11 0 0	—
Hoops	11 10 0 to 12 0 0	—
MIDLANDS—		
Crown Bars	9 5 0 to 10 0 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 17 6 to 9 0 0	—
Gas Tube Strip	11 9 0	—

STEEL. (d)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ¾in. and up	8 7 6	7 12 6
Sections	7 17 6	7 2 6
Steel Sheets, ¼in.	8 12 6	8 10 0
Sheets (Gal. Cor. 24 B.G.)	13 5 0	13 0 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 15 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	7 12 6	—
Soft Billets	6 15 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	7 10 0 to 10 0 0	—
MANCHESTER—		
Bars (Round)	8 17 6	—
,, (Small Round)	7 12 6	—
Hoops (Baling)	10 5 0	10 0 0
,, (Soft Steel)	9 0 0	8 15 0
Plates	8 12 6	—
,, (Lancs. Boiler)	10 0 0	—
SHEFFIELD—		
Siemens Acid Billets	10 0 0	—
Hard Basic	7 2 6 to 7 12 6	—
Intermediate Basic	7 0 0	—
Soft Basic	6 5 0 to 6 7 6	—
Hoops	9 10 0 to 10 0 0	—
Soft Wire Rods	7 10 0	—
MIDLANDS—		
Small Rolled Bars	7 7 6 to 8 0 0	—
Billets and Sheet Bars	5 17 6 to 6 0 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	—
Galv. Sheets, f.o.b. L'pool	13 5 0 to 13 7 6	—
Angles	7 17 6	—
Joists	7 17 6	—
Tees	8 17 6	—
Bridge and Tank Plates	8 12 6	—
Boiler Plates	11 0 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	18/6 to 18/7½
Block Tin (cash)	223 15 0
,, (three months)	223 5 0
Copper (cash)	64 1 3
,, (three months)	64 2 6
Spanish Lead (cash)	21 8 9
,, (three months)	21 12 6
Spelter (cash)	25 17 6
,, (three months)	25 13 9
MANCHESTER—	
Copper, Best Selected Ingots	68 10 0
,, Electrolytic	69 5 0
,, Strong Sheets	94 0 0
,, Tubes (Basis Price), lb.	0 1 1¼
Brass Tubes (Basis Price), lb.	0 1 0
,, Condenser, lb.	0 1 2
Lead, English	23 0 0
,, Foreign	21 15 0
Spelter	26 0 0
Aluminium (per ton)	£107

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/7½ per lb.	
Ferro Tungsten	1/3½ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 2 6	7/6
,, ,, 6 p.c. to 8 p.c. ,,	£22 0 0	7/-
,, ,, 8 p.c. to 10 p.c. ,,	£21 15 0	6/-
,, ,, Specially refined		
,, ,, Max. 2 p.c. carbon	£34 0 0	12/-
,, ,, ,, 1 p.c. carbon	£40 10 0	15/-
,, ,, ,, 0·70 p.c. carbon	£45 0 0	17/-
,, ,, ,, carbon free	1/2 per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (per ton)	£13 10 0 for home	
	£13 10 0 for export	
,, Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale 5/- per unit	
,, ,, 75 p.c.	£20 10 0 scale 6/- per unit	
,, Vanadium	14/3 per lb.	
,, Molybdenum	4/6 per lb.	
,, Titanium (carbon free)	1/2 per lb.	
Nickel (per ton)	£170 to £175	
Ferro-Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.
(*Prices not stable.*)

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	13/9
,, ,, Ell	14/6
,, ,, Splint	16/3 to 17/-
,, ,, Trebles	13/3
,, ,, Doubles	12/3
,, ,, Singles	11/3
AYRSHIRE—	
(f.o.b. Ports)—Steam	13/6
,, ,, Jewel	15/6
,, ,, Trebles	12/6 to 12/9
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	10/9 to 12/9
Screened Navigation	18/-
Trebles	12/3 to 12/6
Doubles	12/6
Singles	11/3 to 11/6
LOTHIANS—	
(f.o.b. Leith)—Best Steam	12/-
Secondary Steam	11/6
Trebles	12/3
Doubles	12/-
Singles	11/3

ENGLAND.

(8) N.W. COAST—	
Steams	24/- to 25/-
Household	37/6 to 50/-
Coke	22/6 to 23/6
NORTHUMBERLAND—	
Best Steams	13/3 to 13/6
Second Steams	11/9 to 12/-
Steam Smalls	9/- to 9/6
Unscreened	11/9 to 12/-
Household	21/- to 27/-
DURHAM—	
Best Gas	15/-
Second	13/3 to 13/9
Household	21/- to 27/-
Foundry Coke	17/6 to 18/-
SHEFFIELD—	Inland.
Best Hand-picked Branch	27/6 to 29/6 —
Derbyshire Best Bright House	20/6 to 21/6 —
Best House Coal	19/- to 20/6 —
Screened House Coal	16/- to 17/6 —
,, ,, Nuts	15/6 to 16/- —
Yorkshire Hards	15/- to 16/- —
Derbyshire Hards	15/- to 16/- —
Rough Slacks	8/6 to 9/6 —
Nutty Slacks	6/- to 7/- —
Smalls	3/- to 4/6 —
Blast-furnace Coke (Inland)	13/- at ovens —
Furnace and Foundry Coke (Export), f.o.b.	18/- to 18/6

CARDIFF (9) SOUTH WALES.

Steam Coals:	
Best Smokeless Large	19/3 to 20/-
Second Smokeless Large	18/6 to 19/-
Best Dry Large	18/- to 18/9
Ordinary Dry Large	17/3 to 18/-
Best Black Vein Large	17/6 to 17/9
Western Valley Large	17/- to 17/3
Best Eastern Valley Large	16/6 to 17/3
Ordinary Eastern Valley Large	16/3 to 16/6
Best Steam Smalls	12/6 to 13/-
Ordinary Smalls	11/- to 12/6
Washed Nuts	17/- to 21/-
No. 3 Rhondda Large	19/6 to 20/-
,, ,, Smalls	14/- to 14/6
No. 2 ,, Large	16/- to 16/6
,, ,, Through	14/- to 15/-
,, ,, Smalls	11/- to 12/-
Foundry Coke (export)	30/- to 37/6
Furnace Coke (export)	27/6 to 30/-
Patent Fuel	21/6 to 22/6
Pitwood (ex ship)	26/9 to 27/-
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	32/- to 35/-
Seconds	24/6 to 27/6
Red Vein	20/6 to 27/-
Machine-made Cobbles	40/- to 42/6
Nuts	37/6 to 42/6
Beans	23/6 to 26/9
Peas	17/9 to 19/-
Breaker Duff	8/- to 8/6
Rubbly Culm	10/6 to 10/9
Steam Coals:	
Large	17/6 to 18/6
Seconds	16/- to 17/-
Smalls	10/- to 12/6
Cargo Through	15/- to 16/-

(1) Delivered. (2) Net Makers' Works. (3) f.o.t. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire. (6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. (d) Rebate 12/6 joists and 10/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our own Correspondent in Paris.)

The Steel Organisation.

By the operation of the Steel Union and the sales *comptoirs*, the iron and steel industry is so closely associated in the three leading continental producing countries that they would all appear to enjoy the same advantages in the distribution of orders. The most important effect of the Union has been a raising of prices, which saved the industry from what threatened to be a real disaster, and the situation improved to the extent that, while German steel makers were kept busy in supplying home needs, the French and Belgians were able to increase steadily their export trade. The Germans were even accorded an increase in their quota of production on condition that they abstained from offering steel for export. The situation has now entirely changed. In Germany the railways and other important consumers have ceased to purchase, and steel makers are therefore obliged to seek foreign business, there having been a notable diminution in the iron and steel production and an increase in exports since the beginning of the year. In France and Belgium, on the other hand, an improvement in demand has been accompanied by a larger output, and steel makers in those countries are hoping to secure an increased quota in order to avoid the necessity of paying heavy penalties for an excess of production. Germany is opposed to any such increase.

Public Works.

The outlook for the mechanical engineering trades appears promising in view of the large number of public works that are being put in hand, partly with the aid of German reparations, and even the railway companies are preparing to distribute further orders for locomotives and wagons. The decision of the Government to take full advantage of reparations is criticised by some of the makers' associations, as it is feared that if German manufacturers are allowed to put down installations of their own machinery, in the new power stations, for example, they may have to be relied upon for repairs and maintenance, and may thereby secure a standing in the French market. Manufacturers insist that reparations should only be obtained for the carrying out of urgent and indispensable undertakings and that the machinery and plant supplied should be of such types as would permit of French makers providing what is necessary for their maintenance. It is obvious, however, that, if reparations are limited, there will be a restriction of activity at home, since the Government has given an assurance that the placing of orders in Germany will be accompanied by the distribution of orders of similar value in France, and unless Germany assists in the carrying out of the considerable programme of public works at home and in the Colonies, it is certain that, under present circumstances, it will have to be postponed indefinitely. At Bordeaux, Havre and other ports, preparations are being made for extensions, while the Colonies are relying upon German reparations for the equipment of ports and construction of railways. In Paris the levelling of the fortifications has removed the barriers between the city and the populous suburbs which cover the department of the Seine, and all the public works now carried out have in view the requirements of this vast agglomeration. The sewage disposal and water supply will necessitate the carrying out of an extensive programme for many years to come. The improvements to the port of Paris, in order to permit of 800-ton barges arriving from the Nord and of providing for the increased traffic which is expected to follow upon the canalisation of the Seine, involve the widening and deepening of canals and the construction of new docks.

Canal Haulage.

As Strasburg looks for its economic prosperity more especially to a development of traffic between the Rhine and the Rhone, many works are being carried out and several new proposals are put forward for increasing the water-borne traffic which is steadily growing. It has become necessary to accelerate the service and prevent congestion through irregular working. One of the schemes under consideration is entirely to suppress animal traction upon the canal from the Rhine to the Rhone. It is found impossible to employ barges propelled by internal combustion engines, owing to the banks of the canal being too light to resist the wash. Endless track vehicles have had to be abandoned because the upkeep of the tow-path is too heavy, and the service becomes disorganised in the event of breakdowns, which are by no means infrequent. It is therefore intended to lay down an experimental 60-cm. gauge track, upon which electric tractors, probably operated on the trolley system, will be run.

Electrification in Morocco.

In a country like Morocco, which appears to possess remarkable natural resources that can only be developed by providing means of transport through regions offering many topographical obstacles, the first duty was to construct a network of railways, and that work is being proceeded with in a way that promises an early completion of a main railway system connecting up Algeria with the chief centres of the Protectorate. Work has naturally been carried on more actively with the Casablanca railway, which is indispensable for the development of the phosphate traffic. The phosphate section of the railway has already been electrified by the distribution of energy under a tension of 60,000 volts from the power station at Casablanca, which will be increased shortly from 18,000 kW to 24,000 kW. The line from the phosphate deposits has a steady falling gradient to the coast, and on this a part of the energy expended on running the trains of 1200 tons is recuperated. Already about 180 miles of railway are electrified, and this will be continued to Marrakech to the south and to Meknes and Fez in the north and east. An hydro-electric power station, of a capacity of 20,000 kW, is being constructed on the Oued Oum er Rebbia, and will be available next year, not only for railway electrification, but for irrigation also.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

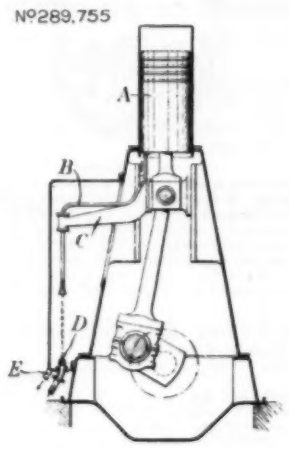
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

289,755. February 23rd, 1928.—IMPROVEMENTS IN OR RELATING TO THE COOLING OF RECIPROCATING PISTONS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

This invention relates to the cooling of the pistons of internal combustion engines, in which the cooling medium is caused to circulate or is injected into the piston itself. In some arrangements which have hitherto been adopted, difficulty has been experienced in preventing the cooling medium from leaking into the crank case, and harmful stresses have been set up, tending to break the reciprocating pipes. In this invention the cooling medium is supplied in the form of a free jet of liquid outside the crank case, which jet enters a pipe outside the crank case con-

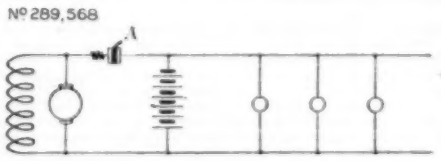


nected to the piston. In the illustration, A is the piston to which the pipe B is connected. This pipe carries the cooling medium and moves up and down with the piston. It is supported by an arm C attached to the crosshead, which arm projects through an opening in the engine crank case. At the end of the pipe is an enlarged funnel-shaped opening or mouthpiece, into which a free jet of cooling liquid is discharged from the nozzle D on the supply pipe. A drain pipe E is provided to carry away any leakage from the system. The cooling water from a piston may be discharged in similar manner, and for double-acting engines the usual hollow piston-rod, for conveying the supply and return of the cooling liquid to the piston, may be employed.—*May 3rd, 1928.*

ELECTRICAL APPLIANCES.

289,568. February 2nd, 1927.—IMPROVEMENTS IN OR RELATING TO SYSTEMS FOR THE GENERATION AND STORAGE OF ELECTRICITY, William John Rickets, of St. Andrew's Works, Crofton Park, Brockley.

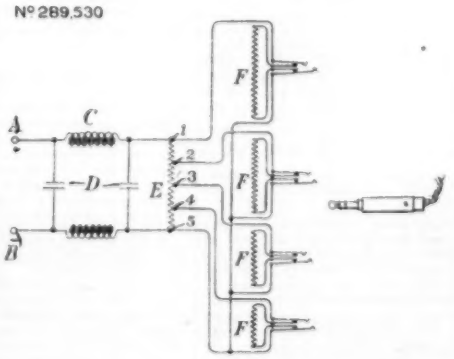
Instead of the usual cut-out employed for preventing a reversal



of the current when a dynamo is charging a battery, the invention proposes to use a metal rectifier. The rectifier is of the copper-oxide type and is simply connected in the main circuit as shown at A. A resistance is also inserted.—*May 2nd, 1928.*

289,530. January 27th, 1927.—MEANS FOR SUPPLYING DIRECT CURRENT OF PREDETERMINED VOLTAGES FROM A SUPPLY MAIN, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2; Reginald Charles Clinker, of "Tryfn," Bilton, near Rugby; and Thomas Wadsworth, of Max Gate, Bilton, near Rugby.

This relates to apparatus which is used for supplying a number

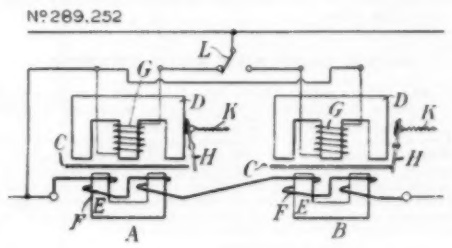


of different direct-current voltages from a single source of supply, which may, for example, be a commercial power supply line. More particularly the invention is concerned with battery eliminators for supplying the filament and plate current of wireless apparatus from lighting mains, although its use is not limited to this particular purpose. A and B are the terminals to which the supply mains or the leads from a rectifier are connected, C and D are the series chokes and shunt condensers respectively which are for smoothing the supply voltage, and E is the potentiometer from the terminals 1 and 5 and the tapping points 2, 3 and 4 of which the desired voltages are derived. Between the negative terminal 5 and each of the other points 1–4 two-way jack type switches are connected and these are joined. To the central contacts of these switches compensating resistances F are connected. When the plug is removed from any switch the compensating resistance is included in circuit in place of the external device connected to the plug, thereby maintaining the current flow through the potentiometer E and consequently the voltage at each tapping point substantially constant.—*April 27th, 1928.*

MEASURING AND TESTING INSTRUMENTS.

289,252. April 19th, 1927.—IMPROVEMENTS RELATING TO ELECTRIC METERS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2, and William Horace Lawes, of 26, Lewisham-road, Highgate, N.W. 5.

This invention relates more particularly to alternating-current induction watt-hour meters, provided with potential and current coils. Meters of this type sometimes suffer from the disadvantage that the movable element is liable to turn under the influence of the current coil alone, even if the potential coil is completely de-energised. According to this invention, a mechanical latching device for holding the movable element of an alternating-current induction watt-hour meter against movement is arranged to be released when the potential exceeds a predetermined value. The drawing shows a pair of similar alternating-current induction-disc watt-hour meters A and B. Each comprises a rotatably mounted induction disc C, a three-pronged potential element D and a U-shaped current element E. The pole pieces of the current element are wound with the current coils F, and the middle pole piece of the potential element with the potential coil G. The meters may be of any well-known or standard design. The arrangement consists of a rockable lever H, which

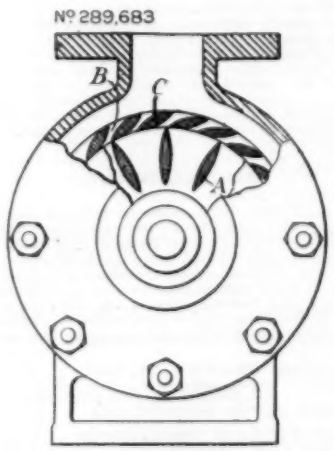


is pivotally mounted, and which has one end arranged adjacent to and transversely of the periphery of the disc C. The tension spring K connected to the other end of the lever acts to bias the lever for clockwise movement about its pivot, in order to bring the lower end against the periphery of the disc, as shown in connection with the meter B. The surface of the end may be roughened or the end may be otherwise adapted so as to apply a sufficient braking effort on the disc C, when in the position illustrated in connection with meter B to prevent movement of the disc. The other end of the lever is provided with a soft iron portion, which is placed in the field of the stray flux due to the excitation of the potential coil G. With this arrangement it will readily be understood that, when the potential core of a meter is excited, the stray flux due to the potential coil will actuate the lever in an anti-clockwise direction, to the position shown in the drawing in connection with meter A. In this case the disc is free to rotate under the influence of the potential and current driving electro-magnets. The two meters illustrated in the drawing may be those forming part of a "two-rate" method of charging, and they are, in fact, shown diagrammatically as being thus connected. The clamping devices illustrated are controlled by the selecting switch L.—*April 26th, 1928.*

PUMPING AND BLOWING MACHINERY.

289,683. August 10th, 1927.—IMPROVEMENTS IN TURBINE PUMPS AND THE LIKE, Jethro Thomas Wade, of Fairfield Works, West Wycombe-road, High Wycombe, Bucks.

This invention has for its object to provide an efficient pump, especially for high-pressure work and in which the power required for driving does not exceed that for which the turbine pump is



designed, whatever the variation in the head of delivery. The propeller is formed with the desired number of radially arranged vanes A with curved outer surfaces, as shown, and the general arrangement of the parts is such that the passages B and stator blades C are substantially tangential to the periphery of the propeller. A multi-stage pump constructed in accordance with the invention is also illustrated.—*May 3rd, 1928.*

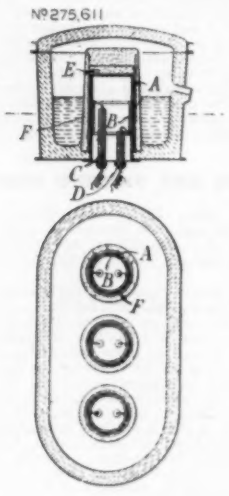
FURNACES.

275,611. July 28th, 1927.—IMPROVEMENTS IN OR RELATING TO HIGH-FREQUENCY ELECTRIC INDUCTION FURNACES, René Dufour, of 28, Avenue du Parc Montsouris, Paris (Seine), France.

The heat generated by induction in the mass to be treated is produced by inductor elements inserted in the mass contained

in the heating chamber of the furnace, and the element is separated from the furnace walls. Each of the inductor elements consists of a tube A of quartz supporting an inductor winding B, which may consist of a bar or tube of conducting materia!

Nº275,611



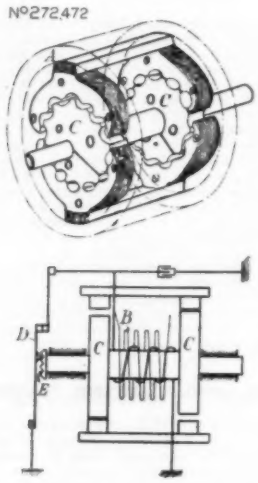
coiled into a helix and connected to the inlet and outlet cables C and D. A powdered substance E forming a heat resistance is introduced between the quartz tube A and the refractory sleeve. —*April 26th*, 1928.

MOTOR CARS AND ROAD TRAFFIC.

272,472. May 20th, 1927.—Improvements in Electric Ignition Apparatus for Explosion Engines, Scintilla Aktiengesellschaft, of Solothurn, Switzerland.

This magneto is said to give a high voltage at very low speeds, and to be suitable for use with engines having any number of cylinders. The machine has a stationary exciter magnet and a stationary ignition coil B. Discs C with pole projections revolve opposite the pole pieces of the stationary exciter magnet, arranged so that the frequency per revolution will be equal to the

Nº272,472



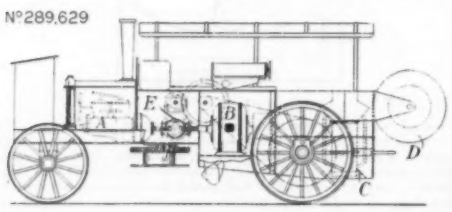
number of pole projections on the flux distributor. For this purpose half the projections on the stationary pole pieces are angularly displaced with respect to the other half, by half the pitch of the grooves. Only a portion of the flux variations per revolution is utilised for producing the spark, the remaining variations being made ineffective by the automatic short-circuiting of the primary coil. The entire iron circuit, with the exception of the exciter magnet, can be built up from laminations The primary coil is short-circuited by means of the interrupter D, which is controlled by a cam E.—*April 26th*, 1928.

MISCELLANEOUS.

289,629. April 25th, 1927.—Improvements in or relating to Self-propelled Cable Ploughing Vehicles, Charles Henry Fowler and Herbert Hodgson, of Hunslet, Leeds.

The object of this invention is to provide alternative sources of electric and mechanical power which may be used through the same road and ploughing gears on a cable ploughing vehicle. The accompanying drawing shows a side elevation of a cable ploughing unit, so fitted. A is an internal combustion engine and B an electric motor, which receives energy from an external

Nº289,629

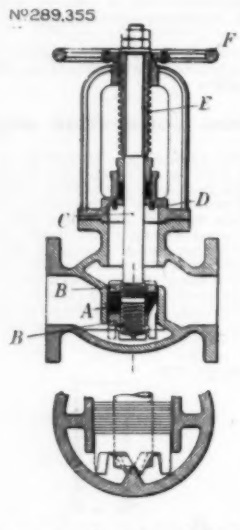


source through a step-down transformer C. There is a slip-ring collecting device which is associated with the cable drum D attached at the rear of the vehicle. The gear-box E, combined with an appropriate arrangement of clutches, bevel and spur gears, sprocket wheels and chains serves to transmit power to the driving wheels and a cable haulage drum, which is shown arranged immediately below the gear-box. Either the internal combustion engine or the motor can be made to drive the vehicle through by means of dog clutches.—*May 3rd*, 1928.

289,355. November 14th, 1927.—A Piston Valve with Externally Adjustable Piston Packing, H. Marmorek, Schellinggasse 12, Vienna 1, Austria, and E. O. Franke, Rannersdorfe No. 22, Nieder-Oesterreich.

This valve is of the piston type and the object aimed at is to provide a simple means of adjusting the packing which makes a fluid-tight joint between the valve and its casing. The valve is composed of compressible packing A, arranged between two

Nº289,355

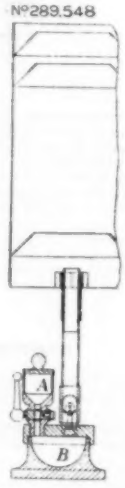


discs B B, which are screwed on to a spindle C with right and left-hand threads. If the valve is in the open position, notches in its upper face engage with pegs D and prevent it rotating, so that by turning the spindle C the discs are closed together, and the packing is tightened. In the lower position of the valve a somewhat similar arrangement is provided for stopping the rotation of the lower disc. The valve is opened and closed by means of the screwed sleeve E and hand wheel F.—*April 26th*, 1928.

289,548. January 29th, 1927.—Improvements in Burners, W. Y. Buchanan, Crogal Glen, Calderbank, Airdrie, Scotland.

The atmospheric gas burner described in this specification is intended to give any characteristic flame coloration and so to provide light of a known wave length for use with optical instruments. The coloration is produced by mixing finely divided chemical salts with the gas before it passes through the nipple. The salt, such as pure anhydrous carbonate of sodium if yellow sodium light be required, is contained in a reservoir A from which it is allowed to pass at a regulated speed through a tap into a bowl-shaped mixing chamber B. Gas is admitted to this chamber through an orifice, not shown, which directs the gas downwards in such a way as to cause an eddy motion to take place, with the result that the powdered salt is picked up and carried in suspension to the top of the Bunsen tube. That tube is surrounded by an opaque chimney having baffles and a window for the emission of light.—*April 30th*, 1928.

Nº289,548



282,717. November 3rd, 1927.—Improvements in or relating to Apparatus for Cooling Fluids, Oscar Simmen, of Erlach, Switzerland.

Whilst the fluid to be cooled is conveyed as by means of a pump through the cooler in the direction of the arrows shown in full lines so that its direction constantly changes, fresh cooling water is admitted through the nozzles A and B and passes through the circulating pipes C and D in the direction of the arrows shown in dotted lines. As fresh cooling water is con-

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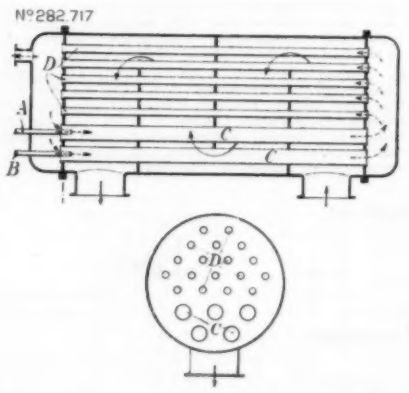

stantly being introduced some of the water which has already passed through the pipes D will again be drawn down into the pipes C, which are of larger diameter, and, owing to this repeated circulation, the quantity of heat carried away is increased. At the same time the increased speed of flow due to the nozzle-like inlet pipes prevents the formation of scale within the pipes and the provision of partitions for repeatedly changing the direction of flow facilitates the heat transmission properties of the apparatus.—*May 3rd*, 1928.

289,599. March 4th, 1927.—Expansion Joints for Piping, Thomas Rose, Long Close Works, Dolly-lane, Leeds.

This specification describes an improved method of forming an expansion joint described in a previous specification. The joint referred to consists of a tubular member bulged outwardly at its centre and having flanges welded to its extremities. The parallel walls of the bulge acting as diaphragms accommodate the expansion movements, but the flattened apex of the bulge remains undistorted. The improvement described in this specification relates to the method of making the tubular mem-

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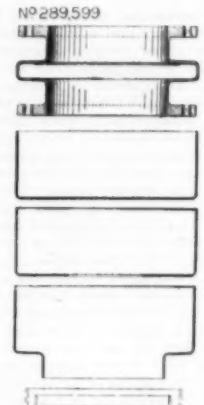

ber. That member, formerly made in parts united together, is now to be made by pressing a circular disc of steel plate into a pan-like form by cutting a hole in the bottom of the pan, by flanging the hole downwards and by pressing in and down the upper portion of the pan wall.—*May 3rd*, 1928.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. Indian Section. "The Port of Calcutta and its Post-war Development," by Mr. S. C. Stuart-Williams. 4.30 p.m.

SATURDAY, JUNE 9TH.

Institution of Municipal and County Engineers.—North-Eastern District meeting at West Hartlepool and Hartlepool. 10.30 a.m.

Institution of Municipal and County Engineers.—Town Hall, Wakefield. Yorkshire District meeting. 2 p.m.

The Society of Engineers.—17, Victoria-street, S.W. 1. Visit to the London Terminal Aerodrome at Croydon. 3 p.m.

THURSDAY, JUNE 14TH.

British Engineers' Association.—32, Victoria-street, S.W.1. Monthly luncheon at St. Ermin's Restaurant. 12.30. Address:—"The New Rating Proposals and their Benefits to Industry," by Mr. Michael Faraday, 1.30 p.m.

Royal Aeronautical Society.—At the House of the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Lecture by Captain Sir George H. Wilkins. 6.30 p.m.

MONDAY TO WEDNESDAY, JUNE 18TH TO 20TH.

The Institution of Heating and Ventilating Engineers—Summer meeting at Blackpool.

WEDNESDAY, JUNE 20TH.

Institution of Civil Engineers: Yorkshire Association.—Visit to G. and T. Earle's Humber cement works.

TUESDAY, JULY 10TH.

The Institution of Electrical Engineers: South Midland Centre.—Local summer meeting. A summer visit to D.P. Battery Company, Ltd., Bakewell, Derbyshire; Haddon Hall; and the Derbyshire and Nottinghamshire Electric Power Company's outdoor sub-station, Ambergate. Assemble Grand Hotel, Birmingham, 8.50 a.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Heap and Digby, Ltd., consulting engineers, of 34, Victoria-street, London, S.W. 1, have now changed their name to Heap and Ryley, Ltd.

Sir W. G. Armstrong, Whitworth and Co., Ltd., ask us to announce that the Right Hon. the Earl of Verulam has been elected chairman of that company in succession to Lord Southborough, who retains his seat on the board of directors.

Werf Gusto (Firma A. F. Smulders), of Schiedam, asks us to announce that Mr. Anderson Rodger, of 38, Victoria-street, London, S.W. 1, having retired from acting as its agent for the British Isles, as from May 1st, 1928, it has appointed in his place Mr. H. E. Macnab, who will have his office at Craven House, Northumberland-avenue, London, W.C. 2.

The Society of Engineers.—We are informed by the Secretary of the Society of Engineers that the following have recently been elected Honorary Fellows of that institution:—Sir Henry Fowler, K.B.E., Sir Herbert Jackson, K.B.E., F.R.S., Lord Lee of Fareham, P.C., G.C.S.I., G.B.E., K.C.B., Sir Ernest William Moir, Bart., M. Inst. C.E., M. Am. Soc. C.E., and Sir Josiah Charles Stamp, K.B.E., D.Sc. (Lond.).